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RADIO-DIAGNOSIS OF PLEURO-PULMONARY AFFECTIONS

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OF THE CLASS OF 1822, YALE MEDICAL SCHOOL
AND OF
WILLIAM COOK WILLIAMS, M.D.,
OF THE CLASS OF 1850, YALE MEDICAL SCHOOL.

RADIO-DIAGNOSIS

OF

PLEURO-PULMONARY AFFECTIONS

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INTRODUCTION

GENERAL CONSIDERATIONS ON THE USE OF RADIOLOGICAL EXAMINATION OF THE THORAX IN CLINICAL MEDICINE

THE progress made during the last few years in the technique of radiological examination has made this new method of investigation very practical, putting it, as it were, within the reach of everyone. The perfecting of the instruments, simplicity of manipulation and the better production of X-ray tubes have changed a process of examination regarded at first as a mere curiosity into a useful scientific and practical method. Those who have once made use of it cannot dispense with it, and the time is coming when the information furnished by radiological examination will be as indispensable as that obtained by means of the stethoscope. In fact, radiology (exclusively surgical in its beginning and used in examination of fractures and the search for foreign bodies) has gradually extended its province in an extraordinary manner. Like all methods of any value, it rapidly grew and is growing every day. Cautiously used by Professor Bouchard in examining the pleura and lungs, it has now become truly medical. It has entered the physiological and pathological study of all the important organs, and recently Vaquez and Bordet have demonstrated its value in the study of the heart and aorta, while Béclère has pointed out all that may be expected in exploring the digestive tract.

FAVORABLE CONDITIONS FOR EXAMINATION OF THE THORAX

The Roentgen rays penetrate solid bodies. It is to this special physical property that they owe all their value, but the penetration is not uniform; it varies on account of the quality of the rays emitted and especially on account of the

density of the bodies penetrated. A collection of bodies of different densities will give, then, on the radioscopic screen a series of shadows varying in value, and this variation will be the more marked the greater the difference in specific gravity of the bodies examined. From these facts it is easy to see that the thorax presents most favorable conditions for examination. The lungs filled with air form on each side of the thorax two organs of very light density which are seen on the radioscopic screen as two clear areas on which the adjacent organs of a much greater density stand out remarkably. In this manner the contours of the heart and the aorta, made more opaque by the large quantity of blood they contain, appear clearly, as well as the costal grill, the outline of the sternum and vertebral column, made more dense by their bony structure and their richness in mineral salts.

On the other hand, the slightest pathological lesion of the pulmonary tissue bringing about an appreciable modification in the density of the parenchyma appears as an abnormal shadow on the screen which will easily attract the physician's attention. In this way the most favorable conditions are realized for the physiological and anatomical examination of the thorax by Roentgen rays.

IMPORTANCE OF THIS EXAMINATION

The importance of this examination is considerable, particularly to the pleuro-pulmonary organs, which are all that concerns us here. By this process new evidence will be obtained very different from that furnished by other methods but which will be added to it and increase in large proportion the resources of clinical investigation.

Whereas up to the present time auscultation and palpation have played the primary part, visual inspection having been content with simply observing the form and contours of the blood-vessels without noting anything of their contents, visual observation in medicine now takes on a value as great as that which it has in actual life. The physician

is no longer blind and he must use his eye as well as his finger and his ear to perfect his practice. Thanks to the Roentgen rays the physician is now easily able to see through the thoracic wall to the deep-seated organs which hitherto were hidden; their functioning and outline can be observed and their minute structure analyzed. At once the superiority of this method supersedes all others, for palpation and auscultation give information only as to the condition of those organs which are close to the thoracic wall; auscultation reveals only lesions superficial enough to transmit to the ear perceptible sounds, while the eye can observe lesions that are concealed in the deeper tissues. No method of exploration can determine as well as radiological examination the topography of pleuro-pulmonary lesions. Their extent, their localization in difficult cases make what Claude Bernard has aptly called "a living autopsy."

No other method of exploration demonstrates so clearly and simply the functions of the heart and lungs, which are of so much importance. It shows without the cardiograph the pulsations of the auricles and ventricles and the aorta. It estimates without the spirometer the respiratory value of the lungs; shows the movements of the diaphragm, the intercostal spaces and displacement of the mediastinum in inspiration and expiration.

NECESSITY OF COMBINED MEDICAL EXAMINATION

The radiologist must be a physician. This method of examination should not be employed alone and take the place of others. That would be a grave mistake. If it is more brilliant than the older method, it is not so well tried out and should be assisted by the older methods.

In fact, sight is not everything, but it is necessary to interpret what is seen and to draw conclusions useful for a diagnosis. The difficulty of interpretation demands a very accurate knowledge of anatomy, physiology and pathology and consequently the radiologist must be a physician. The radiologist must have a well-grounded knowledge of the

development and progress of disease and the complications which may arise. It is only on these conditions that useful medical work can be done and the serious errors of interpretation avoided which will inevitably occur without a thorough medical education on the part of the radiologist.

Radiological examination shows on the screen or plate only lines and shadows—black and white. It shows the forms, extent, location, degree of opacity of these shadows as well as their relation to different organs. It gives no information of their nature, their anatomical value or development. Information lacking to the radiologist can be furnished by physician, patient, family history, study of the development of his disease, and finally and especially, by a complete physical examination, investigation of functional disturbances, analysis of urine, sputum, etc.

A wise interpretation can be made only in the light of all these facts without neglecting any. It must then be decided which should have precedence and why. In short, after a careful and detailed analysis, a synthesis ought to be made. In that diagnosis consists.

In certain cases radiological examination may be conclusive and may totally change the superficial diagnosis. In other cases it will simply confirm the diagnosis. Even when *a priori* it seems useless, it ought not to be neglected, as it is often in that case most interesting and furnishes to the physician most unexpected data. It is always the physician, however, who ought to decide in the last analysis.

The physician ought to become interested in radiology. If the radiologist ought to be a physician, it would be well also for the physician to be, in a less degree, a radiologist.

It would be very useful to everyone if the bond between physician and specialist were closer. Every physician ought to be interested in this new method, to know the elementary principles and learn to read the chest on the screen or plate. If he cannot personally examine the patient, he ought to assist. The radiologist will thus be furnished with the facts he has not always time to collect. He will discuss with the

physician the interpretation of the images, and the diagnosis will gain in accuracy.

Radiology has become a useful science and will become more so every day, provided there is greater collaboration between physician and radiologist.

PART I

METHODS OF EXAMINATION

CHAPTER I

RADIOSCOPIC EXAMINATION OF THE THORAX

NORMAL IMAGES.—Before attempting to interpret pathological changes it is absolutely essential to understand thoroughly the normal thorax. As has already been seen, the number of pictures is unlimited. They vary with the position of the patient, the height of the tube, the quantity and quality of the rays. It would be impossible to describe all of them and moreover quite useless. But among these positions there are a certain number which are constantly used and which may be called classic or fundamental positions. These are as follows: frontal or anterior, dorsal or posterior, left transverse, right transverse, right anterior oblique, and left posterior oblique.

Frontal or anterior position.—In this the patient faces the screen and is exposed to the Roentgen rays from back to front. This position is one of the best for obtaining a view of the whole of the thorax. The image of the thorax is produced on the screen as a rather large median shadow of irregular form, on each side of which are two large, clear areas which constitute the lungs.

The median shadow is formed by the superposition of the vertebral column, the sternum and all the organs of the mediastinum, particularly the large vessels: aorta, pulmonary artery, venæ cavæ. At the base the shadow is quite markedly enlarged on the left side because of the heart.

The form of this median shadow is quite regularly rectilinear in the upper two-thirds of its right border; the middle third corresponds to the superior vena cava; in the lower third it presents quite often a rounded dilatation which corresponds to the contour of the right auricle. Its left border is composed of three successive arches. The first

of these is the aortic arch, situated at the very top, just below the internal border of the clavicle. The middle arch corresponds to the pulmonary artery; the inferior arch, much the most important, forms the contour of the left ventricle. All these arches are animated by perceptible pulsations, at times very distinct, which show clearly the alteration between the pulsations of the ventricle and those of the pulmonary artery and the aorta.

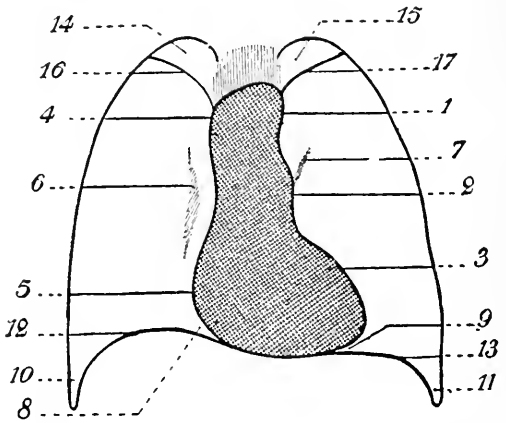


FIG. 3. FRONTAL OR ANTERIOR POSITION

1. Aortic arch. 2. Pulmonary arch. 3. Ventricle arch. 4. Border of the superior vena cava. 5. Right auricle. 6. Shadow of right hilus. 7. Shadow of left hilus. 8 and 9. Cardio-diaphragmatic sinuses. 10 and 11. Costo-diaphragmatic sinuses. 12 and 13. Convexity of diaphragm. 14 and 15. Apices of lungs. 16 and 17. Clavicles.

With this median shadow must be included the shadow of the hilus of the lung, visible especially at the right because at the left it is partly covered by the shadow of the heart. This shadow, which is far less dense, is detached from the median shadow toward its center and separated from it by a narrow, clear space. The form is a crescent, of which the lower horn is a little more elongated and prolonged obliquely downward and to the right. The significance of this shadow has been much discussed. Among the organs which constitute the hilus it is probable that, in the normal state,

these are especially the vascular organs: the pulmonary arteries and veins which contribute to its formation; the bronchi seem to play only an unimportant part. In the pathological condition this shadow is enlarged, elongated and very perceptibly thickened. It appears then that its composition becomes more complex and that the hypertrophied and inflamed glands, bronchic and peribronchic sclerosis add perceptibly to the opacity of the vascular element.

The lung spaces are made up of two large, symmetrical clear areas, situated on each side of the median shadow, the contours of which they aid in defining. The shadow of the ribs is also very clearly seen, symmetrically arranged, crossing obliquely the clear zone from top to bottom and from without inward and forming the costal grill.

Each lung is triangular in form. The upper part is naturally separated from the rest by the shadow of the clavicle and the portion thus circumscribed corresponds to the picture of the apex of the lung. The base is limited by a movable shadow with sharply defined contour, convex in form. It is the diaphragmatic dome which falls on inspiration and rises on expiration. The extent of this movement furnishes excellent indications of the respiratory capacity of the lungs; normally, it ought to be equal on both sides.

The level of the diaphragmatic dome is not the same on the right as on the left. The liver, in raising the diaphragm, elevates its outline in a marked manner. The convexity of this outline helps to form, together with the adjacent shadows, a sort of cul-de-sac or sinus which is very important to recognize.

The costodiaphragmatic sinuses correspond to the external extremities. These are largest and deepest and their presence ought always to be looked for. Their diminution or their disappearance always indicates a pathological process. At the internal extremities are two other smaller sinuses called the cardiodiaphragmatic sinuses. Their disappearance is usually caused by a pleural or pericardial process.

In women, the breasts cast two symmetrical shadows over the lower part of the thorax, sometimes obscuring the bases and more or less completely effacing the contour of the diaphragm and the costodiaphragmatic sinus. They should not be taken for pathological shadows. If the breasts are raised upward and outward the normal thoracic clearness reappears.

The importance of examination in the frontal anterior position is thus demonstrated. It gives a view of the whole of the thorax; it permits one to become orientated so that it will be possible to complete, in the other positions, the study of those organs which have especially attracted the attention of the observer.

Dorsal or posterior position.—In this position the patient's back is to the screen and the rays penetrate from front to back. The image obtained is analogous to that of the inverse frontal position. It, however, differs from it in certain details. The outlines of the median shadow and of the heart are more deformed. The heart and the aorta being further from the screen, their projection is magnified. The shadow of the hilus of the lungs is less clearly visible. On the other hand, the scapula shadow stands out more clearly and the costodiaphragmatic sinuses and the respiratory movements of the diaphragm are perfectly distinct.

Transverse position.—The patient is turned ninety degrees so that either the right or the left side is to the screen. There are, then, two transverse positions: the right transverse, in which the patient is exposed to the rays from left to right, and the left transverse, in which he is exposed from right to left.

In the first of these positions the liver comes in contact with the screen; it will therefore be useful for the examination of this organ—the determination and localization of an abscess or hydatic cyst. In the second position it is the heart which comes nearest to the screen and there can be obtained in this manner interesting data regarding the anterio-posterior diameter which it is impossible to appre-

ciate in the dorsal and frontal positions. The thoracic portion of the descending aorta can also be seen very well, and it can be definitely ascertained whether an aneurysm, already brought out by the examination in the other positions, involves this portion of the vessel.

Oblique positions.—These positions are innumerable, but two are especially well known because they are considered the classic positions for the examination of the aortic arch and the œsophagus.

Right anterior oblique position: Examination of the aortic arch. In order to obtain this position, from the frontal position, turn the patient slowly f om right to left in such a way as to bring the right nipple vertical line in contact with the screen. He will thus be penetrated from back to front and from left to right. In this way the median shadow is shut out, and looking at the screen, the observer will see successively the shadow of the vertebral column pass to the left while that of the sternum, scarcely apparent, deviates toward the right. Between the two the shadow of the aorta appears clearly and, more particularly, that of the aortic arch. Between the aorta and the vertebral column is a clear space, narrow and elongated, which is called the median clear space; the middle of this space is crossed by a gray shadow more or less dense, due to the shadow of the hilus of the lung. This position is therefore perfect for the study of the aorta, of the mediastinum, from which all the organs are separated, and in an accessory way, for the study of the hilus of the lungs and the search for tracheo-bronchial adenopathy.

Left posterior oblique position: Examination of the œsophagus. This position is obtained starting from the dorsal, by turning the patient from right to left until the left scapula comes in contact with the screen. The rays will then penetrate from front to back and from right to left. The dissociation of the median shadow will be made in an analogous manner but gives an inverse image of it. A clear space becomes visible from top to bottom on the left border

of the vertebral shadow, which is the œsophagus. The thoracic tract of the œsophagus can be entirely studied and its general shape and functional capacity verified.

The study of these fundamental positions ought never to be neglected, but it is very important to complete the examination by studying a whole series of intermediary positions. The radiologist can never obtain too many images or familiarize himself too thoroughly with all their aspects under the most varied angles of incidence and from all the positions should learn to verify his findings. In difficult cases a true interpretation can sometimes be made from a small detail obtained in some one position.

Procedure.—In all these cases it is best to make at first a complete examination followed by an examination in detail. Always begin by studying frontal and dorsal, then fundamental oblique and transverse positions and finally a whole series of intermediary positions.

Complete Examination.—In the complete examination an attempt will be made to ascertain whether the images are quite normal in all positions, whether they have kept their general form and regularity of contour. In the frontal and dorsal positions the comparison of the right and left sides will be made. The symmetry or irregularity of the forms, contours and dimensions will be looked for,—the conformity or the difference in clearness as well as the mobility of the organs and their regularity in functioning.

Detailed Examination.—An examination in detail will then be taken up, and it should be kept in mind always that the organ one wishes to examine ought to be placed as near as possible to the screen in order to avoid deformation. The diaphragm will be used in order to concentrate the light at the special point to be studied so that contours will appear more clearly. Finally, the quality of the rays ought to be varied in order to bring out its structure, to dissociate shadows of different density and thus to have an anatomical conception of it as clear as possible.

In the study of the pleuro-pulmonary affections which is

the subject of this book, the attention of the observer ought to be directed more especially to a certain number of points. He ought to ascertain particularly the condition of the apices, hilus, sinuses, interlobes, and carefully examine the diaphragmatic respiration.

Examination of the apices.—In general the apices of the lungs are less clear than the bases; their functioning is less active, the air penetrating there in less quantity. This diminution of clearness is still more accentuated in obese or in muscularly developed individuals. It is not necessary to pay much attention to a diminution in clearness of the apices provided it is equal and symmetrical on both sides. But if this diminution is unilateral, it becomes immediately more important. It is important to make use of the diaphragm and to vary the quality of the rays.

Examination of the hilus.—The shadow of the hilus deserves also special study. When it is normal, it does not signify that the pleuro-pulmonary tissues are intact; but when it is abnormal—more extensive and denser—there most often exists a pleuro-pulmonary reaction requiring investigation.

Examination of the interlobes.—It is useful to determine the condition of the interlobes. A shadow at this level always indicates an old or recent pleural process. To make this evident it is necessary not only to employ the diaphragm and to vary the quality of the rays, as in the hilus or apex, but also to modify the height of the tube, as Béclère has pointed out. In the dorsal position the tube should be raised to the height of the head; in the frontal position, it should be lowered to the level of the pelvis. In this way the normal rays penetrate the interlobe in its greatest thickness and the best conditions are found for obtaining an image. (See Interlobar Pleurisy, Sclerosis of the Interlobe.)

Examination of the sinuses.—The costodiaphragmatic sinuses ought to be the subject of serious examination; they ought to be studied separately and comparatively. The inferior angle of the sinus ought always to be acute and deep;

it ought to increase and clear on inspiration, to partly fill and darken on expiration. If it appears abnormal, one should compare it with the opposite side, bearing in mind the modifications which may be produced on the right by the proximity of the liver, on the left by the stomach according to its state of vacuity or of repletion.

Examination of the diaphragm and respiration.—Finally, the study of respiratory movements is particularly important. It should include the lung, ribs and diaphragm.

Lungs.—It is known that the pulmonary image becomes decidedly illuminated on inspiration and darkened on expiration. This phenomenon is particularly visible towards the bases. This clearness ought to be carefully compared; a defect in illumination on one side is related to a defect in pulmonary expansion on the same side; and it will be necessary to investigate the cause of it.

Ribs.—It is equally useful to compare the image of the costal grill on each side. A diminution of the intercostal spaces coincident with greater obliqueness in direction and a narrowing of the pulmonary field on the same side suggests a collapse of the thoracic wall such as is observed after pleurisy.

Diaphragm.—Finally, the greatest attention should be given to the study of the functioning of the respiratory pump, of which the diaphragmatic dome constitutes the piston. It is necessary to see whether the course of the piston is sufficiently extended, is equal on both sides, and whether the movements are regular and continuous or irregular and jerky. The slightest trouble in the functioning of this important apparatus assumes at once a grave significance that an experienced radiologist ought never to neglect.

It is only after having made use of all these examinations, as a whole and in detail, that the observer from all these findings can affirm whether the thorax he has just examined is normal or pathological.

Abnormal Images.—When examination has shown that an abnormal image is present, it ought to be studied and

all deductions should be drawn that may be useful for diagnosis.

A complete diagnosis from a radioscopic examination alone ought never to be made at once, even in the most favorable cases. It is always necessary to have clinical data and to endeavor to make it agree with the radioscopic examination.

The radiological study of abnormal shadows gives only their form, contours, localization, extent, multiplicity, the value or density of these shadows, and their relation with adjacent organs.

Let us take the most favorable cases—those in which the form and contours of the abnormal shadow are entirely characteristic. Two typical examples may be chosen: Given a patient in the examination of whom is seen on one side of the thorax a very dense base limited by a mobile horizontal line, more or less suddenly displaced with each motion but always remaining horizontal in the different changes of position. It is certainly the line of fluid level. Above this dark zone there is a very clear zone, due probably to the presence of a collection of gas over the fluid. This lesion is often completely obscured, difficult to detect clinically, and the radioscopic examination in such cases may therefore be of great assistance in directing diagnosis; but it cannot determine it entirely. In fact, it cannot indicate whether it is a question of a hydro or of a pyopneumothorax, and it only shows very imperfectly, if at all, its cause and its origin. The rest of the information should be obtained clinically.

Given another patient who shows in the thorax an extended, opaque shadow of regularly spherical form, with sharply defined contours. The form and contours of the shadow are characteristic, yet the diagnosis is not evident. It may be a question of a mediastinal tumor, an aneurysm of the aorta, or a thoracic cyst. Suppose that by radioscopic examination a study is made of the form, relation and topography, the first two hypotheses are eliminated and the

existence of a thoracic cyst is affirmed. It will be impossible most often to assert whether the cyst is dermoid or hydatid.

Beside its form and contours an abnormal shadow is also characterized by its localization. A denseness localized in the apex suggests pulmonary tuberculosis. But this localization may also be seen in certain cases of pneumonia, in certain cases of cancer of the lung, etc. A localized density at a base suggests a sequela of pleurisy but may be due to other causes.

The *extent* of an abnormal shadow is equally important to ascertain. A very extended shadow occupying all one side of the thorax, accompanied by a displacement of the mediastinum calls to mind pleurisy with effusion; but certain pulmonary processes may also produce this image and often it is produced by a combination of the two processes—pleural and pulmonary.

The *multiplicity* of abnormal shadows is produced in the lungs by chronic pulmonary tuberculosis and bronchopneumonia; but in a lesser way also by a number of other affections.

The *value of the density* of the shadow in question is also of some importance. An extended, very opaque and homogeneous shadow will suggest rather a fluid collection. Under the same conditions a limited shadow will more often be associated with a gland, a calcified tubercle, or with a foreign body.

Finally, a *study of the relation* of the abnormal shadow with the adjacent organs will help more especially to bring out this or that organ as being the cause of the formation of the shadow.

Conclusion.—Such, in the main, are the facts which the radioscope may furnish the clinician. The physician ascertains on the screen only the shadows and light areas which constitute normal and abnormal shadows. All deductions useful in medicine are based on the analysis of these shadows. Not all this information will be useful, but if any one part becomes so, it is enough to prove the value of the method.

In conclusion, and it cannot be repeated too often, final and complete diagnosis ought not to be demanded of radioscopy. That is not within its province. Radioscopy is not a supernatural science. It is only a method of exploration, different from the others, perhaps more perfect, whose part it is to furnish some indication and interpretation for diagnosis. In difficult cases, when there is a question of diagnosis, this method will be of some value but it should remain for the physician to make final diagnosis.

PART II

RADIOLOGICAL STUDY OF THE PLEURÆ

IN the normal state the pleuræ do not show on radioscopic examination. The thickness of the layers being everywhere the same, no abnormal shadow is seen on the screen; as for the pleural cavity, it is purely potential; the lung, owing to its own elasticity, fills the entire thoracic cavity and gives it its clearness.

The pleural layers are visible only in the pathological state, when local inflammation has produced a thickening of the wall, or a fibrinous deposit on its surface (dry pleurisy).

The pleural cavity is apparent only when it is abnormally filled either with fluid (pleurisy with sero-fibrinous or purulent effusion); or with a gas (pneumothorax); or with both at once (hydropneumothorax or pyopneumothorax).

Effusions of the pleura may involve either the entire pleural cavity (pleurisy of the large cavity) or only a part of this cavity. In that case the pleurisy is circumscribed (encysted pleurisy), and according to the portion of the pleura involved it is known as interlobar, diaphragmatic, or mediastinal pleurisy.

The different pleural manifestations and their radiological characteristics will now be taken up.

CHAPTER I

PLEURISY OF THE LARGE CAVITY

PLEURISY WITH EFFUSION.—This is one of the forms most often seen clinically. The diagnosis is ordinarily easy enough by the means usually employed: percussion, palpation, auscultation. However, there are cases where these are not sufficient.

Radiological examination may, therefore, under certain conditions help determine the diagnosis; but it will furnish, above all, considerable information on the development of the disease, increase or decrease of effusion, compression and displacement of the surrounding organs, the re-establishment of pulmonary functions; in general, it will serve to throw light on the prognosis.

Radioscopic examination of pleurisy was first practised by Bouchard in 1896. Bergonié and Carrière in 1899 did work based on eleven observations. Barjon took up the question in 1904 with his colleague P. Courmont at the "Société Médicale des Hôpitaux de Lyon" and in Fayard's thesis (Lyon, 1904), called attention particularly to the oblique direction of the fluid level, in relation to the curve of Damoiseau, which the radioscopic examination explained.

GENERAL APPEARANCE OF THE THORAX.—When the thorax of a patient with pleurisy of the large cavity is examined on the screen, one is impressed with the almost total obscurity of the diseased side, while the normal side retains all its clearness. This obscurity is nearly uniform, but more intense, however, obliquely from the base. At this level it becomes impossible to distinguish the contour of the diaphragm, as the respiratory movements are abolished, or the lateral "cul-de-sac," which is completely effaced by the effusion. At the top a clearness persists which is the more

decreased and obscured the more abundant the effusion. Under the pressure of the fluid a lateral deformation is produced corresponding to the displacement of the mediastinum and of the heart. This displacement is shown on the screen by a triangular enlargement of the median shadow, the size of which increases progressively from top to bottom and stands out against the clear background of the normal side.

Upper limit of the effusion: Appearance of the apex.—The upper limit of the effusion does not show a sharply defined outline in pleurisy. The opacity diminishes gradually; and

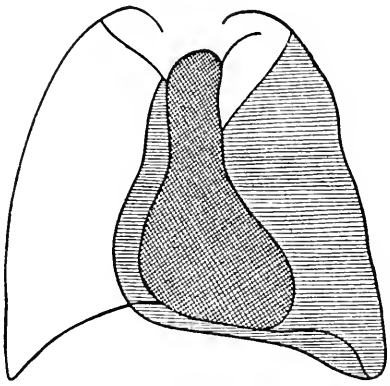


FIG. 4. PLEURISY LEFT SIDE

Displacement of heart and mediastinum, lowered position of diaphragm. Upper limit of effusion slopes downward from without inward.

little by little, through a series of transitions, one passes imperceptibly from shadow to light without being able to exactly say where one stops and the other begins. However, by studying it carefully and using a lead diaphragm, one can determine this upper outline and define its form.

The difficulty of this interpretation explains up to a certain point the difference of opinion of authors who have ascribed to this line sometimes a convex, sometimes a concave, sometimes a horizontal form. It is fair to add in explanation that this form is modified quite appreciably according to the height of the effusion, so that the variation

in their descriptions may perhaps be due to the fact that their observations were made under different phases, either of increase or decrease of the pleurisy.

In an effusion of moderate amount this line takes an oblique direction from the top downward and from without inward; commencing from without at the apex of the axilla and ending inwards towards the hilus of the lung. This position corresponds to the so-called curve of Damoiseau. This is the most common form and the one which ought to call to mind at once a pleural effusion.

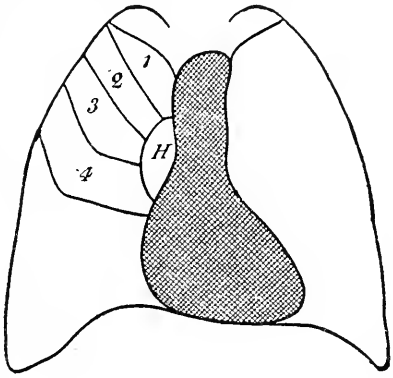


FIG. 5. PLEURISY OF THE LARGE CAVITY

Modifications of the fluid curve. H: hilus region. 1 and 2: oblique line, curve of Damoiseau. 3 and 4: broken lines, subsiding effusion.

When the pleurisy increases, the light triangle retained at the apex by this curve diminishes little by little until it disappears, and there may occur a time when the obscurity becomes complete throughout the hemithorax. On the contrary, if the effusion decreases, the line is lowered; is transformed at first into a broken line and tends more and more towards the horizontal. Even when the clearness of the apex is retained, it is always perceptibly less than that of the opposite side. This diminution does not signify that there are lesions in the pulmonary parenchyma, but only a functional inhibition of the compressed lung, in which the

penetration of the air is much reduced on account of the suppression of the diaphragmatic respiration on the side of the effusion.

Curve of Damoiseau.—It is a principle that every large effusion of the pleura which decreases shows this decrease on radioscopic examination by a gradual lowering of the line of the oblique shadow, which always remains directed from above downward and from without inward.

This statement is confirmed by clinical findings. When pleurisy decreases, there always reappears sonority, fremitus and respiration in the paravertebral triangle situated between the scapula and the vertebral column. At this time the effusion is circumscribed by a parabolic curved line which, starting from the apex of this triangle, rises toward the axilla and descends on the anterior wall, reaching the sternum obliquely towards the hilus of the lung, so that it comes back almost to the same level from which it started. This is the so-called curve of Damoiseau.

The existence of this curve is proved by clinical and radiological examination; it appears on the screen as the oblique line that has just been described. By studying this oblique line, in the usual position of the curve, and by examining the variations and deformations that it undergoes, such as its rise and fall from this position, the cause and the reason for this unusual picture can be understood.

In fact, in all these successive deformations this oblique line always ends inward towards a fixed point which is the hilus of the lung.

Therefore, if we study the progress of the fluid inversely, that is to say up to the period of increase, it is easy to understand the formation of the curve, if we bear in mind this anatomical fact, that the lung, free from all parts in the pleural cavity, is only retained and fixed at a single point: that is at the level of the hilus where the bronchi and vessels enter and at its inner margin where the ligament of the lung is attached.

When an effusion is produced in the pleura, the fluid,

following the laws of gravity, collects at the base above the diaphragm. In proportion as it increases, it presses back the lung from the base upward, which, on account of its elasticity, becomes very much compressed. This goes on in this way until the level of the fluid reaches the region of the hilus. At this point, the lung being fixed offers a serious resistance to the pressure of the fluid. Meeting resistance on the inner side, the fluid presses outward, where the lung, being free, is more easily moved; the fluid increases, infil-

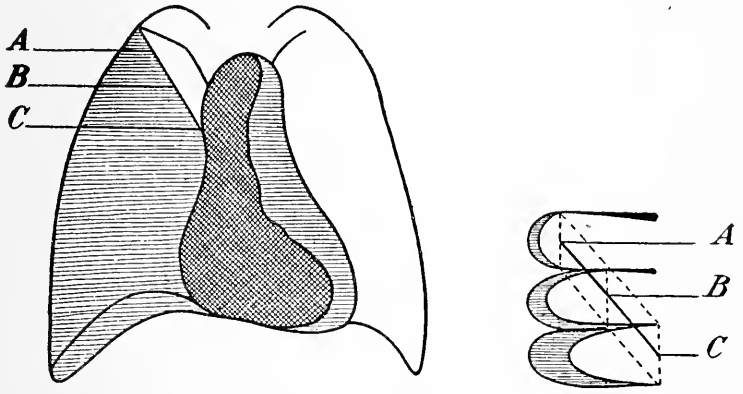


FIG. 6. EXPLANATION OF THE CURVE OF DAMOISEAU
A, B, C. Horizontal sections of the different levels of the thorax, showing the separation from the fluid and its difference in thickness without and within.

FIG. 6. THE SAME
Superposition of sections A, B, and C. Location of the fluid at the level of each of them, showing the formation of an inclined plane.

trating between the two layers of the pleura and separating the lung from the wall. The level of the fluid remains always horizontal and its depth increases more quickly without than within, and this difference in depth is seen on the screen by an oblique, dark line from above downward and from without inward.

In summing up, three factors influence the production of the curve of Damoiseau:

1st. Gravity. 2nd. The relative mobility and elasticity of

the lung. 3rd. The fixity of the lung within, in the middle portion by the hilus and lower down by the ligament.

A fourth very important factor is necessary to produce this curve. In order to be seen the patient must either be seated or standing. If he is recumbent, in the dorsal or ventral position, the curve disappears on account of the mobility of the fluid which, by gravitation, flows in front or in back through the length of the costo-vertebral space. This, too, is remarkably well demonstrated on radioscopic examination.

From this study it is seen that the curve of Damoiseau is not a fixed quantity. It is a kind of unstable equilibrium between the fluid and the lung in relation alike to the mobility of the fluid, the elasticity and fixity of the lung towards the hilus. It is an essentially transitory phenomenon which for its production requires a definite amount of fluid, a given position of the patient, a lung free from adhesions and a pleural cavity without any form of obstruction. In encysted pleurisy the curve of Damoiseau never occurs. In order to be produced, the limit of the effusion would have to occur in a particularly fortunate manner, so that the curve might be produced completely.

All these clinical findings, which have been well known but poorly accounted for, have become simple and easy to understand, owing to the explanation afforded through radioscopic examination.

Study of the diaphragm.—In all forms of pleurisy of the large cavity, there is absolute immobilization of the diaphragm on the side affected. This immobilization is rather difficult to determine when the effusion is well established and when it obscures almost the whole of the thorax. However, on the left side it is relatively easy. The presence of the gastric air bubble, which allows the inferior side of the diaphragm to be lighted up, shows this immobility. When the stomach contains no gas, it can be introduced artificially. It is entirely different on the right side, where the obscurity produced by the liver is continued without any line of de-

marcation from that of the effusion. But if the diaphragm is difficult to see during the full period of pleurisy, it is quite otherwise at the onset and the retrogression of the condition.

It can be shown, in fact, that the paralysis of the diaphragm precedes the effusion and that it survives its disappearance. In one case Barjon assisted very materially in demonstrating this first phenomenon. A patient was admitted into the service with a severe stitch in the side which had just appeared during the day. He was radioscoped immediately and there was shown on the diseased side a very clear hemithorax; the contour of the diaphragm and the lateral cul-de-sac were perfectly intact and there was no trace of fluid in the pleura. But the diaphragm was completely immobilized and no respiratory movement was seen, while on the opposite side it was very extensive. The next day another examination showed that the effusion was produced in the interval and that it occupied already half of the hemithorax. Immobilization of the diaphragm, therefore, precedes effusion, only it is rarely that this fact can be observed, the patients ordinarily being seen only when effusion is established.

On the other hand, the diaphragm during the period of retrogression of the effusion may constantly be observed, and it is easy to see that its paralysis, or better still its immobilization, sometimes persists for a very long time after complete absorption of the fluid. This point will be taken up later in connection with prognosis and the end results of pleurisy.

In certain cases of hydrothorax, in patients with Bright's disease, the movements of the diaphragm were frequently retained in spite of the existence of an abundant effusion. This perhaps may have an interesting significance which might permit a distinction to be made between a purely mechanical effusion (and it is well known how rare they are) and those which are accompanied by definite pleural inflammation. By combining clinical, radiological and cyto-

logical study of effusions a solution of this interesting question would undoubtedly be reached.

It might be asked whether in pleurisy at onset there really exists a true paralysis of the diaphragm, and whether it is not rather an involuntary immobilization brought about by the patient due to the painful stitch in the side which the respiratory movements exaggerate.

Displacement of the heart and mediastinum.—When pleural effusion is sufficiently large, there is produced a characteristic deformation of the radiological image of the thorax. Through the pressure of the fluid, the median partition of the thorax, or mediastinum, which is most movable, is displaced to the healthy side, including the heart and other organs that it contains. The other walls, formed by the ribs, firmly attached in front and back, offer a strong resistance. All movement is carried on by the diaphragm which is lowered and the mediastinum which is pushed back. The displacement of the heart and of the mediastinum is more accentuated the more considerable the effusion is.

The determining of this displacement is therefore very important from many points of view and nothing is easier than to show it by radioscopic examination. It is seen on the screen as an elongated triangular shadow, bordering on the median shadow. Its base is on the diaphragm on the opposite side and its apex corresponds to the sterno-clavicular articulation.

The presence of this shadow enlightens and confirms diagnosis. It furnishes valuable indications as to the amount of the effusion and the expediency of puncture. It helps to explain the mechanism of the displacement of the heart, formerly much disputed.

For a long time it was believed that the displacement of the heart took place as a turning movement on its own axis, and that the base remaining almost immobile, it was the apex especially which was displaced. In pleurisy of the left side, for example, it was believed that the apex, describing a large arc of a circle, came to be placed under the right

breast. The pulsation observed at this level was erroneously attributed to the apex.

As Bard has very rightly said, everything that pulsates is not necessarily the apex; and this author has had the distinction of showing by clinical means only that the heart, instead of undergoing such a twisting movement, was simply pushed back "en masse," preserving always its same direction. Radioscopic examination has only confirmed the opinion expressed by Bard. It is easy, by following the development of a pleurisy of the left side, to verify the fact that the heart is pushed over "en masse" and that the auricles extend over to the right of the median line. The auricles are recognizable by their rounded form and by their pulsations. As for the apex, it tends more and more to approach the shadow of the sternum until it is obscured behind it, when the displacement is considerable.

Development and Retrogression. Modifications after Puncture. It is easy to follow by radioscopic examination the fluctuation of an effusion and thus to verify the clinical findings.

When it increases, the clear superior triangle is seen to be reduced more and more and the clearness even disappears completely; the hemithorax is then entirely obscure from apex to base. The displacement of the heart and mediastinum is accentuated and the shadow ultimately covers all but a third of the pulmonary field on the healthy side. The effusion is then considerable, and indications are for an immediate thoracentesis.

When the fluid retrogresses, the oblique line which forms the curve of Damoiseau is lowered more and more in proportion as the clear triangle is enlarged. Soon the curve disappears and there remains only a diffuse shadow with poorly defined contour, occupying the lower third of the pulmonary field. At this time the displacement of the heart and mediastinum has disappeared and there only persists a complete obliteration of the lateral cul-de-sac, with immobilization of the diaphragm.

In large effusion, immediately after a puncture, even if as much as one liter of fluid has been withdrawn, it is often astonishing to find on radioscopic examination no modification of the image of the thorax.

The obscurity is always so intense and so extended that it appears as if nothing had moved. This phenomenon may be explained in the following way: when a certain quantity of fluid has been withdrawn from the thorax, each of the walls contracts a little by reason of its natural elasticity and adapts itself to the new volume of its contents. As a result of this, the thoracic convexity diminishes, the ribs are slightly lowered, the diaphragm is elevated a little, pushed up by the abdominal pressure, and the mediastinal partition approaches the median line. All these movements compensate for this loss of fluid and the level of the fluid is not altered.

This equilibrium is only temporary and during the following days there is either a new increase or a definite decrease of the pleurisy.

Radiological diagnosis.—As has already been said, the principal rôle in the diagnosis of effusion of the large cavity belongs to the clinician. Most often diagnosis is simply confirmed by radioscopic examination.

However, under certain circumstances, radioscopy plays a more important part: clinically signs are present, either without the existence of any effusion; or, on the other hand, an effusion is present without stethoscopic signs.

Pseudo-effusions.—In the first case, it is pseudo-effusion. The patients in question have all the signs of pleurisy of the large cavity: dullness, fremitus, abnormal breathing, egophony and aphonic pectoriloquy; and yet there is no pleural effusion.

This phenomenon may be present under many circumstances and radioscopic examination has here a great value. It demonstrates, in fact, that in spite of these deceptive symptoms, the pleura is free of fluid, the hemithorax is perfectly clear from apex to base, the diaphragmatic dome

stands out clearly, and if the respiratory movements are weak and lessened in extent, the diaphragm is not completely immobilized. It is certain, therefore, that there is no effusion.

This negative diagnosis ought to suggest a positive diagnosis if we take into consideration all the indications furnished by the history, clinical examination, the development of the disease, and radioscopic examination.

Grancher described some years ago, under the name of "spleno-pneumonie" a clinical syndrome which, under the appearance of pleurisy, is not accompanied by any effusion. It is a particular condition of the lung in which consequently thoracic symptoms always ought to predominate. It is produced in bronchitis, pulmonary congestions, pneumonias. It may be a form of incipient tuberculosis. Finally, it is met with in the course of general infectious diseases, such as rheumatism and typhoid fever.

If in such a case radioscopic examination shows that there is no effusion, it can also bring out abnormal pulmonary shadows which may serve to confirm the diagnosis of spleno-pneumonia. But there may be met with, outside of this condition, clinical signs of pseudo-effusion.

Barjon drew attention some time ago (Lyon Méd., 1912, Vol. I, p. 908) to two cases of subdiaphragmatic affections producing this complete syndrome without there being, however, any fluid in the pleura. One of these patients had an abscess of the liver, the other, suppurated cyst of the same organ. Similar facts have been observed in certain cases of subphrenic abscess.

In these conditions radioscopic examination shows the persistence of thoracic clearness as far as the base. The contour of the diaphragm has retained all its clearness, but it is raised higher into the thoracic cavity with reference to the opposite side; its respiratory movements are much decreased or abolished; and all these signs attract attention away from the subdiaphragmatic region.

It is in these cases of pseudo-effusion that radioscopic

examination is most useful, because it enables us to make sure that there is no fluid in the pleura.

Inversely, when a pleural effusion exists which does not give any stethoscopic signs, or only pulmonary signs, the findings furnished by radioscopic examination may still be very useful, but they have not as absolute a value and their interpretation is a matter of more care. This may be produced under three conditions: either with a large total effusion, or with an extended effusion associated with pulmonary lesions, or, on the contrary, with a small amount of fluid.

Large total effusion.—When the effusion is total, the clinical signs may be confined to dullness with absence of fremitus. On account of the compression of the lung, no abnormal breathing, egophony, or aphonic pectoriloquy is heard. The radioscopic image shows total obscurity of the whole hemithorax; no clearness remains at any point, neither the line of level, nor the characteristic curve; but uniform opacity throughout.

The screen shows only one thing, but to this a certain amount of importance ought to be attached; namely, the displacement of the heart and mediastinum, which ordinarily is considerable. This sign alone ought to direct diagnosis which probably can be confirmed by exploratory puncture.

It is exceptional for a cyst or a tumor, even if large enough to cause a displacement of the mediastinum, to be able to obliterate entirely the clearness of the pulmonary field throughout the hemithorax. Barjon has never observed it. A small clear zone at the apex or at the base always persists, limited by a curve which generally takes a direction exactly inverse to that of pleurisy. This detail alone ought to be sufficient to attract attention.

Association of pulmonary lesions.—The effusion may be of medium amount but associated with more or less extensive pulmonary lesions, which modify considerably the stethoscopic signs and the radioscopic image.

These conditions may occur in certain cases of tuberculosis,

but it is especially during the course of pneumonia that the difficulties of diagnosis are most often encountered.

Sometimes pneumonia occurs in which recovery is not normal. Sometimes resolution does not take place; sometimes after a transitory defervescence the temperature rises again and the general symptoms are aggravated. The question is whether it is pneumonia with slow resolution, a new pneumonic attack, or a pneumonic pleurisy, either interlobar or of the large cavity, which may require intervention. The clinician is often unable to state this positively.

Auscultation may reveal miscellaneous pleural and pulmonary signs difficult to interpret. The dullness persists, fremitus is scarcely perceptible, the breathing is more bronchial than pleuritic, loose râles of all kinds are sometimes heard as far as the base; it is impossible to affirm the existence of effusion.

The question of interlobar pleurisy will be taken up later on.

If the base is clear and the contour of the diaphragm is retained, while a shadow, or shadows, occupy the upper part of the lung, it may be affirmed that the large pleural cavity is not involved. But if the base is obscure, interpretation becomes more difficult.

There may be a total obscurity from apex to base either when there is present massive pneumonia, a superposition of an effusion of the base and an hepatization of the apex, or when there exists a solid lung in the fluid which causes the slight effusion to rise as far as the apex.

In such a case, displacement of the heart and mediastinum cannot even be demonstrated as it often does not exist on account of the small amount of fluid. Radioscopy is, therefore, unable to solve the question. It is necessary to be careful and to guard against too positive statements.

Very few pulmonary processes are capable of producing total and uniform obscurity of the hemithorax and always in these cases the existence of a pleural effusion should be suspected. But if its existence after radiological examination

alone cannot be affirmed, it will be necessary to rely on the findings of this examination sufficiently to demand one or more exploratory punctures.

Slight effusions or effusions in retrogression.—The same difficulties are met with here. Very often it is impossible to say whether fluid still remains in the pleura. The radioscope shows a diffuse shadow of the base, always more extensive outward than inward, without exact outline. The diaphragm is always immobilized, but displacement of the heart or mediastinum is no longer seen.

This shadow may depend on the persistence of a small quantity of fluid, but it may remain long after its absorption. It is due to the presence of exudates not yet absorbed, to the persistence of atelectasis of the lung which has been compressed for a long time towards the base, and to paralysis of the diaphragm. Radioscopy is therefore not able to give information on this point and besides at this stage it is of no great interest.

Difficulty of Diagnosis in Children.—It is often difficult to affirm the presence of pleural effusion in children by radioscopic examination alone. Because of the smallness of the thorax the obscurity is never as important as in the adult and in spite of the use of medium penetrating rays the entire costal grill continues to be perceptible. Besides, the elasticity and mobility of the ribs allows much more margin to the effusion and as a result the displacement of the heart and of the mediastinum is much less pronounced in them than it is in the adult. These modifications of the radioscopic image ought not to cause the diagnosis of an effusion to be dismissed, but caution should be used.

Diagnosis of the Type of Pleurisy.—This diagnosis ought to be exclusively clinical. Radioscopy might, if necessary, furnish some information as to the existence of other concomitant thoracic lesions which have a more or less active part in the formation of an effusion; for example, pulmonary lesions, a tumor of the lungs or mediastinum, an aneurysm of the aorta. But it can give no indication of the serofibrinous,

purulent or hemorrhagic condition of the fluid. Formerly it was thought possible to distinguish radioscopically between purulent and serofibrinous effusions; it was claimed that the purulent effusions were less opaque than the others. This distinction has been found inaccurate, and only the findings drawn from the topography and the extent of the shadows can be taken into consideration. That is to say that, except in the case of interlobar pleurisy, where the probabilities are in favor of purulence, radioscopic examination furnishes no exact findings to establish this diagnosis.

Radiological Prognosis of Pleurisy: its after Effects.—When a pleurisy is systematically examined in process of resolution, either by spontaneous retrogression, or after thoracentesis, a series of modifications is observed which from their appearance and their more or less rapid progress furnish interesting elements of prognosis. It is the same after empyema operations in the course of a purulent pleurisy.

After a serofibrinous pleurisy the pulmonary functions may be seen to be rapidly re-established in favorable cases. From the time that the fluid is absorbed, the base of the hemithorax becomes visible again; the contour of the diaphragm reappears, the respiratory movements are re-established. The extent of the respiratory movement becomes very quickly equal to that of the other side, the lateral cul-de-sac resumes its original form, and in a few weeks it is impossible to find by radioscopic examination the least indication as to the side on which the effusion was produced. This happens in the most favorable types and it must be recognized that it is rather rare.

In other cases, the development is less rapid but the prognosis remains nevertheless favorable. The obscurity of the base and the immobilization of the diaphragm persist for several weeks or months; then gradually the respiratory functions are re-established and no further trace of the old lesion remains.

Certain pleurisies, on the contrary, leave indelible marks.

Adhesions persist between the two folds of the pleura, ending in partial or total symphysis. This results in retraction of the thorax with lowering of the ribs, narrowing of the intercostal spaces and inclination of the costo-vertebral angle. The diaphragm remains adherent to the base of the lung, the respiratory movements never regain their mobility and the pulmonary functions are never entirely re-established. The heart is often displaced in the movement of retraction of the thorax, bound by adhesions and fixed in an abnormal position (dextrocardia or sinistrocardia). In these patients retrospective diagnosis of an old pleurisy can be made by radiological examination several years later.

The rapidity with which the pulmonary functions are re-established during the first few days after a pleurisy permits one to determine in advance to which type it belongs.

In purulent pleurisy, after empyema operation, but only in the first days following intervention, Destot and Violet have shown the signs on which prognosis should be based. The deduction is made from examination of the pulmonary permeability and expansion.

Pulmonary permeability is estimated by the degree of clearness of the lung during respiration. Expansion is the functional tendency of the lung to fill the pleural cavity.

Prognosis is favorable if the permeability and expansion are satisfactory. Spontaneous recovery ought to be expected.

Prognosis is less favorable if permeability remains normal and expansion is lacking. In this case spontaneous recovery cannot be expected until the obstacle to expansion is removed; that is to say, until decortication is resorted to.

Finally, prognosis is distinctly unfavorable if the permeability and expansion are both lacking. In this case, decortication becomes altogether insufficient and the cavity can be filled only by the breaking down of the wall. Resection of the ribs must then be done.

Radioscopic examination would be able in this case to

indicate at the same time the prognosis and the method of intervention.

Dry Pleurisy.—The radiological study of dry pleurisy is much less important than that of pleurisy with effusion.

In *partial dry pleurisy* there are small, local, well defined lesions of irregular surface, fibrinous deposits, thickening of the folds (of the pleura) and adhesions. These lesions are usually caused by underlying pulmonary lesions, and in the abnormal shadow resulting it is impossible to determine radioscopically what belongs to the pleura and what to the lungs.

Auscultation, when it discloses the presence of friction or a diminution of pulmonary expansion, recognizes dry pleurisy. Most frequently these lesions can only be suspected and their existence can be inferred only after the demonstration of superficial pulmonary foci, because it is known that these lesions are usually accompanied by local pleural reactions, especially in the tuberculous.

Total or very extensive dry pleurisy is seen after pleurisy or during the course of some chronic extensive pulmonary affection, such as slowly progressing tuberculosis. It is then seen as partial or total symphysis. Nothing is more difficult than the clinical diagnosis of these symphyses.

Radioscopic examination often gives valuable indications for detecting them. In recent cases it shows a relative obscurity of the base. The diaphragmatic contour has lost its clearness and is often deformed. Its mobility is reduced to a large extent; sometimes even the respiratory movements are completely suppressed. The costodiaphragmatic sinus is reduced in breadth and depth, is half filled, even sometimes totally effaced.

In older cases a certain deformity of the thorax is found in addition. There exists a retraction of the hemithorax with a narrowing of the pulmonary field. The ribs deviate, incline towards the vertebral column, and approach one another as if to efface the intercostal spaces. The heart may be involved in this movement of general retraction, displaced and fixed in dextro or sinistrocardia.

Unfortunately these radioscopic symptoms are not constant and there may exist symphyses which nothing has revealed. The following observation is interesting from this point of view: A tuberculous patient with advanced bilateral lesions presented the following radioscopic appearance: very extensive diffuse obscurity of the left side, occupying the upper two-thirds of the lung; an elongated gray shadow extending to the diaphragm; immobilization of the diaphragm and effacement of the costodiaphragmatic sinus; at the right, a less extensive obscurity occupying only the upper part of the lung. Contour of the diaphragm and sinus normal. Respiratory movements were retained with a rather large amplitude. In this patient pleural symphysis of the left side was thought of; on the right, it was supposed only some adhesions existed in the upper part of the chest, the site of old lesions. Autopsy showed a total double symphysis, very adherent on both sides and it was necessary to dissect the lung in order to separate it from the diaphragm.

The only difference was in the extent of the pulmonary lesions. On the left these lesions were enormous; all the upper lobe was infiltrated, softened, pitted with small cavities; the lower lobe was full of tuberculous bronchopneumonic foci, almost confluent, many of which were already softened in the center. On the right, there were found extensive lesions in the upper lobe; the middle lobe was almost intact; and the lower lobe contained only some undiscovered, very small patches of tuberculous bronchopneumonia. Finally, the left lung was reduced to zero from a respiratory point of view, while the right was to a great extent still permeable to air.

It is to this cause that the difference in radioscopic appearance ought to be attributed and not to the symphysis, which was equal on both sides.

The symphysis immobilized the left lung which no longer functioned. The pulmonary portion which filled the sinus had become opaque owing to the tuberculous lesions and the resulting impermeability. The diaphragm had become

immobile since the lung had lost all elasticity and respiratory function.

On the right the lung still functioned to a very appreciable degree; the portion of the lung which filled the sinus had remained clear and the movements of the diaphragm were still quite extensive.

This shows that symphysis is not everything; that it is not always sufficient in itself to immobilize the diaphragm and that the lung plays a very important rôle in the mechanism of the respiratory movements. It is the stimulus of these movements and starts the respiratory reflex. While the lung is able to do this, adhesions, even when very adherent, are not enough completely to immobilize the diaphragm.

This shows, besides, that there may exist a total symphysis without its being manifest on the radioscopic screen by any apparent symptom. Inversely, an extensive purely pulmonary process is sufficient to obscure the base, to efface the sinus, to diminish the amplitude of the respiratory movements to the point of immobilization—all this without there being any adhesion.

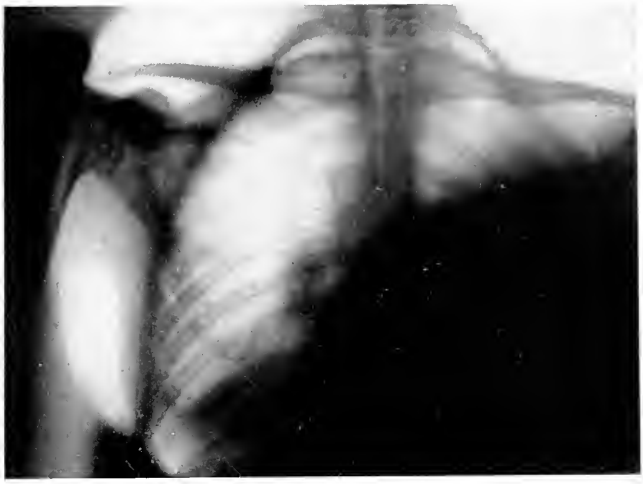
CHAPTER II

CIRCUMSCRIBED AND ENCYSTED PLEURISY

PLEURISY may be circumscribed in a portion of the pleura only, and serofibrinous purulent effusions may form and become encysted in a defined area of the pleural sac without communicating with the large cavity. This cyst may form in any portion of the pleura. Andral has described an encysted pleurisy of the apex, and more recently Agasse-Lafont has reported another case of localization in the right apex (Soc. méd. des Hôp., 1910). But there exist, however, some points of predilection for this process. The pleurisy then takes the name of the region where it is encysted. There is, therefore, in the order of its importance: interlobar, diaphragmatic and mediastinal pleurisy. Pleurisy of the region of the hilus will be also mentioned. Sometimes these forms remain separate; sometimes they are combined. Complex forms are then produced such as pleurisy "en équerre" of Chauffard, made up of a combination of the diaphragmatic and mediastinal forms.

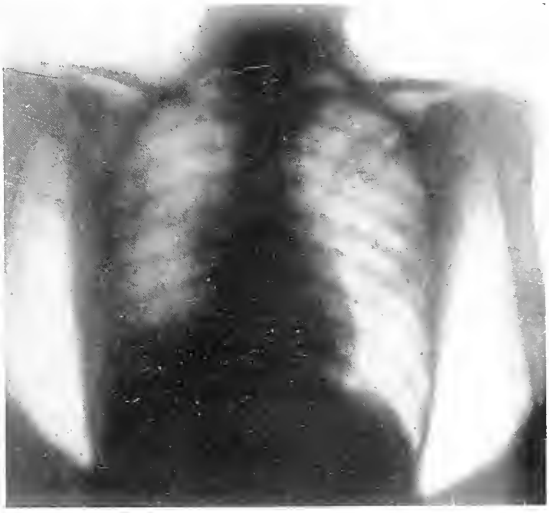
The radiological study of encysted pleurisy is extremely interesting. Clinical diagnosis is hard to establish. Radioscopic examination therefore becomes of the greatest use in detecting slight effusions, but is not limited to that alone. Pleurisy most often is purulent and necessitates intervention. It is not sufficient to determine its presence, but it is also necessary to ascertain exactly its location and indicate from what point it should be approached.

INTERLOBAR PLEURISY.—Among the encysted pleurisies, interlobar pleurisy is one of the most important, as much from its frequency as from the difficulty of diagnosis. The lesion, located in one of the interlobar spaces, is deeply situated and consequently difficult of access by the usual means



RADIOGRAPH 1. PLEURISY OF THE LARGE CAVITY WITH MARKED EFFUSION. CONDITION COMPLETE

Pleurisy on right. Abundant fluid in the large cavity. Obscurity is uniform and complete of the lower two-thirds of the right hemithorax. Superior triangle clear. Light zone between the dark part and the light part; oblique direction of this line of separation above and below and from without inward. Marked deviation of the heart and mediastinum to the left.



RADIOGRAPH 2. TUBERCULOUS PLEURISY OF THE LARGE CAVITY ON THE RIGHT. PERIOD OF REGRESSION, DIMINUTION OF FLUID

Tuberculous pleurisy of the large cavity on the right, progressive regression. There is not much fluid elsewhere. Persistence of obscurity at the right base due to the presence of exudates and a pulmonary atelectasis.

The convexity of the diaphragm is not seen, nor the costo-diaphragmatic sinus. The respiratory movement is completely abolished. Enlargement of the hilus shadow on the right (tuberculous glands of hilus). Discrete, disseminated shadows in the upper part of both lungs. Pulmonary lesions.

of exploration. In 1899 Guinon insisted on the difficulty of diagnosis of this type of pleurisy. Radioscopic examination is therefore indicated in these cases.

Interlobar pleurisy, like that of the large cavity, may be dry or accompanied by effusion.

Interlobar pleurisy with effusion.—This is the most interesting form because it admits of surgical treatment and the radioscopic examination is almost indispensable in determining the indications for it. The effusion is, in fact, almost always purulent and must be evacuated.

In exceptional cases this effusion may be serous. Gerhardt published a case in 1907, where absorption was spontaneous.

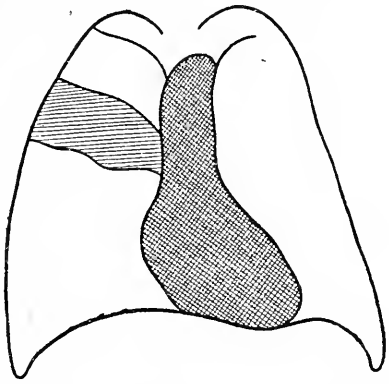


Fig. 7. INTERLOBAR PLEURISY

Diagnosis was made by radioscopic examination and the progressive diminution of the effusion up to its complete disappearance could be followed on the screen. Similar findings have been reported by Sabourin (Rev. de Méd., 1909) in tuberculous patients.

Whatever the nature of the effusion, the radioscopic image remains the same and it is especially important to recognize this in order not to overlook the diagnosis.

The radioscopic image is quite characteristic. It consists of a transverse opaque band which entirely crosses the clear pulmonary field. The lung is therefore divided into three

zones: a dark zone between two clear zones—one above it, the other below it. This image is superimposed on what has been clinically termed "matité suspendue" and considered a characteristic sign of this affection.

The dimensions of these three zones are variable according to the case, and especially variable on the right where two interlobes exist. The distance between the two interlobes being slight, sometimes no important modification occurs in the topography of the radioscopic image. The respiratory movements of the diaphragm are usually retained.

The intermediary opaque band shows as well outlines of variable form. Sometimes it is defined by two almost horizontal lines; sometimes one of these lines curves under the pressure of the fluid and the outline of the shadow becomes convex either above or below.

Finally, if the effusion still increases and the tension extends to the interior of the sac, a convexity of both sides forms and the image takes on an irregularly oval or rounded form. This appearance may suggest a cyst, but the contour is never as regularly spherical and the clinical development is quite different.

The remaining characteristic of interlobar pleurisy is the existence of a continuous transverse opaque band, cutting from one side to the other the clear pulmonary field without any break in continuity. This is what distinguishes it radioscopically from an abscess of the lung, the location of which is quite different. The shadow of the abscess never goes from one side to the other; it never obstructs the thorax, and is surrounded either totally or at least on two or three sides by a clear zone.

However, at the very onset, during the formation of interlobar pleurisy (as observed by Barjon in one case) the image may not be complete at first. The shadow may be localized at one end of the interlobe or at the side of the hilus, for that is where infection usually takes place. Radiological diagnosis is almost impossible at this time as glands of the hilus or a tumor must be considered. In a few days, however (15

days in Barjon's case), the image becomes complete; the interlobe is affected in its entirety and the characteristic band obstructing the hemithorax throughout its width appears.

The diagnosis of interlobar pleurisy is relatively easy when the image is complete. Radioscopic examination is indispensable in confirming it. In many cases clinical errors will be avoided, for in such patients this is often mistaken for tuberculosis or pneumonia progressing towards suppuration, in which prognosis is much more serious. The formation of pus may be anticipated, or better still, indication for surgical intervention established.

This indication having been established, radioscopic examination determines accurately the point of entrance for intervention. It is easy, in fact, by means of rays of normal incidence to draw on the skin the exact contours and the definite outlines of the purulent collection in order to indicate to the surgeon at what intercostal spaces it ought to be approached.

This intervention is the most favorable solution and that is why its exact indication is so important. In fact, evacuation by vomica is very often insufficient and under these conditions suppuration remains a long time and with it cough, fever and purulent expectoration.

False recovery through vomica.—Radioscopic examination is even very useful after the evacuation. Diagnosis which was only suspected through evacuation may be confirmed when examination is made during the days immediately following; progress of recovery may be followed and the cavity may be gradually seen to fill up. Finally, the existence of an old interlobar pleurisy may be recognized and a diagnosis corrected which was misleading because of lack of knowledge of the former facts of the case.

After evacuation, the radioscopic image of interlobar pleurisy appears as a partial pyopneumothorax. In the lower part of the cavity a small quantity of pus remains which could not be evacuated and gives a rather limited opaque shadow, while above this there exists a clear zone

filled with air which entered at the time of evacuation and which is constantly renewed through the bronchial fistula. These two zones—clear and opaque—are limited by a horizontal and mobile line which recalls exactly the image of pyopneumothorax of the large cavity. It differs from it in its smaller dimensions and its higher position.

Sometimes, following a more complete evacuation, the cavity may be entirely emptied and the line of level disappears in the course of a few hours. At this time only a clear cavity is seen, surrounded by a more opaque zone, due to the thickening of the layers of the pleura, which resembles to a certain degree the image of a pulmonary cavity. But presently a new purulent secretion is produced and the line of level reappears.

Sergent has already rightly insisted on pseudo cures of interlobar pleurisy by evacuation. He has shown cases of suppuration persisting for several months. Barjon has had occasion to observe a still older case in which radioscopic examination was of the greatest service.

It was a man about forty-five years old, of tuberculous appearance, who entered the hospital during Barjon's service. Seventeen years previously he had had pleurisy, concerning the nature of which he gave no information. Since then he had had a continual cough and expectoration which was purulent, often with hemoptysis. He had grown thin and had a slight temperature. Upon examination dullness was noted over almost the whole of the left lung and auscultation revealed the presence of rather numerous moist râles with a marked decrease of the vesicular sound. The right lung appeared sound. Clinically very little was indicated except pulmonary tuberculosis.

Radioscopic examination showed the existence of a slight partial pyopneumothorax. The tuberculous serodiagnosis was negative; the sputum contained no Koch bacilli. On questioning the patient carefully, the existence of a previous evacuation was discovered, dating back seventeen years. In spite of the length of time since this manifestation, a

RADIOGRAPH 3. OLD PURULENT PLEURISY OF THE LARGE CAVITY. EMPYEMA. PERSISTENCE OF A THORACIC FISTULA WITH PNEUMOTHORAX

Marked clearness of the inferior external portion of the right hemithorax. Pneumothorax, suppuration drained by the thoracic fistula, no retention. Lung adherent and sclerous. Sclerous lines in the entire upper part of both lungs, especially on the right.

Displacement of heart and mediastinum to the left, held by adhesions.

Intervention—Large costal resection, drainage of the cavity. Recovery.

RADIOGRAPH 4. OLD INTERLOBAR PLEURISY ON THE LEFT OF 17 YEARS' STANDING. PERSISTENCE OF PARTIAL PYOPNEUMOTHORAX WITH BRONCHIAL FISTULA

Obscurity of almost the entire left hemithorax with a clear oblong portion in the superior external region. Partial pyopneumothorax. Retraction and deformation of the thorax, narrowing, sloping and drawing together of the ribs. Scoliosis due to an old suppurated interlobar pleurisy incompletely emptied by vomica.

Intervention—Incision, resection of 3 ribs, drainage of the cavity. Recovery.

diagnosis of old interlobar pleurisy was made. This diagnosis was confirmed by the physician who had attended him at that time. Since then the bronchial fistula had never closed; the patient had slight evacuations from time to time and suppuration had persisted. The patient was transferred to the service of Dr. Delore, who made a large costal resection, which was followed by a gradual recovery. The success of this case was entirely due to radioscopy.

Sclerosis of the interlobe.—Dry pleurisy of the interlobar spaces does not usually present any physical sign. Clinical diagnosis of it is therefore absolutely impossible. Anatomically this pleurisy ends in sclerosis of the interlobe. In this form it no longer gives any stethoscopic sign but it becomes discernible by radioscopic examination and on this account it interests us.

M. A. Béclère was the first to draw attention to this point in 1902 in an article in the "Presse médicale." He showed that sclerosis of the interlobe could not be determined by the usual examination but that it was necessary to follow a certain technique if it was to be brought out. On account of the rather oblique position of the interlobar fissure it shows very little thickness in the anterior or posterior examination, when the tube is on a level with the middle of the thorax, which is the normal position for an examination.

The result of this is that it does not give an appreciable shadow. It is sufficient to modify the position of the tube in such a way that the rays of normal incidence pass through the same axis of the interlobar space in order to produce a very clear shadow on the screen. In fact, in this position the sclerotic band is penetrated by the rays at its greatest thickness and it appears on the screen as a linear, more or less dense, opaque shadow and follows an oblique direction from apex to base and from without inward, parallel to that of the interlobe.

To obtain this result, it is necessary, in the anterior position, to raise the tube to the height of the head and, in the posterior position, to lower it to the level of the pelvis.

In fact, in each of these two positions the interlobe is penetrated by the rays either from apex to base, or vice versa, at its point of greatest thickness. M. Béclère has demonstrated this by means of a sheet of cardboard placed behind the screen. When this sheet is held vertically, it does not give any perceptible shadow, but if it is turned slowly so that its position becomes oblique, it commences to throw a shadow on the screen and finally gives a clear, opaque, linear shadow with contours sharply defined, when in the horizontal position. It is exactly the same in regard to the interlobe, but as this is fixed, the tube must be moved in order to demonstrate it. This form of dry interlobar pleurisy is found especially in the tuberculous.

The diagnosis of interlobar sclerosis is interesting and radioscopic examination deserves the credit, for other methods of investigation are negative; however, it is of very little practical use and does not show the therapeutic value of demonstrating a suppurative interlobar process.

Diaphragmatic Pleurisy.—Diaphragmatic pleurisy is not rare, but the clinical diagnosis is always difficult; it ought to be investigated very carefully. The clinical picture with sudden onset which is classically described: acute pain, distressing dyspnœa, hiccoughs, etc., is most often lacking. Local physical examination sometimes gives little information. Radioscopy is therefore of the greatest use in determining these locations.

This type of pleurisy may be purulent, in which case it is rarely primary but usually secondary to an infection which is most often of abdominal origin. It may often be serous or dry. These two forms are much more frequent, of an insidious nature and are ordinarily met with in tuberculous cases.

Purulent diaphragmatic pleurisy.—This form is the most important. It does not usually follow pulmonary lesions; therefore the preservation of the clearness of the overlying lung ought to be studied. In exceptional cases it might form following purulent pleurisy of the large cavity, which

later would become encysted. In this case the anterior pleural lesions would have obscured in certain measure the corresponding hemithorax; but most often it is a distant infection (appendix abscess, gastro-intestinal ulcer or cancer, lesions of annexa, etc.) which determines this localization.

The clinical picture of it is always serious, even without the striking characteristics which are so often lacking: general health poor, tachycardia, a markedly intermittent temperature. It is assumed that there must be local suppuration. The local symptoms (dullness, absence of fremitus and respiratory sounds) are very important when they exist, but they may pass unperceived or may be entirely lacking. This may occur if the collection is deep, limited, and entirely surrounded by a layer of healthy lung.

Under these conditions radioscopic examination assumes great importance. It shows ordinarily an opaque shadow, in the form of a horizontal band, several fingers in width, and situated at the base of the hemithorax. The value of this band should be determined—whether it signifies a collection, and whether it is above or below the diaphragm.

When the dark band shows a clearly defined superior contour and when the lung remains clear above, there is every indication of a localized collection.

If the band does not occupy the entire width of the hemithorax, if the external portion has remained clear and the costodiaphragmatic cul-de-sac permeable, it is located above the diaphragm, beyond any possible question.

If the band occupies the entire width without any lateral clear spaces, it is impossible on casual inspection to decide the question.

Clinically it has been proposed to make diagnosis by puncture. If the discharge is greatest on inspiration, the collection is subdiaphragmatic; on the contrary, if it is greatest on expiration, the collection is above the diaphragm. An important objection may be made to these theories; that is, that the diaphragm being immobile, these signs most often cannot be determined.

Radioscopic examination can furnish this information to some degree. If the band is situated on the left, recourse may be had to inflation of the stomach. This technique easily lights up the inferior surface of the diaphragm, if the collection is above; and if it is below, the stomach will appear displaced to the right or else the air chamber will remain either only slightly apparent or invisible.

When the band is at the right, it is confused with the shadow of the liver and it becomes quite impossible to differentiate them radioscopically.

Finally, in a case where the radioscopic examination shows a small, clear pocket, apparently filled with gas, in the middle of the abnormal shadow, this finding favors a subphrenic collection, unless an evacuation has previously been made.

Whatever may be the difficulty of exactly locating the lesion, either above or below the diaphragm, radioscopic examination will always be able to show the existence of a collection which ought to be evacuated in either case. It will indicate at what point it is best to approach it, and the surgeon will determine through intervention whether the origin of the suppuration was above or below the diaphragm.

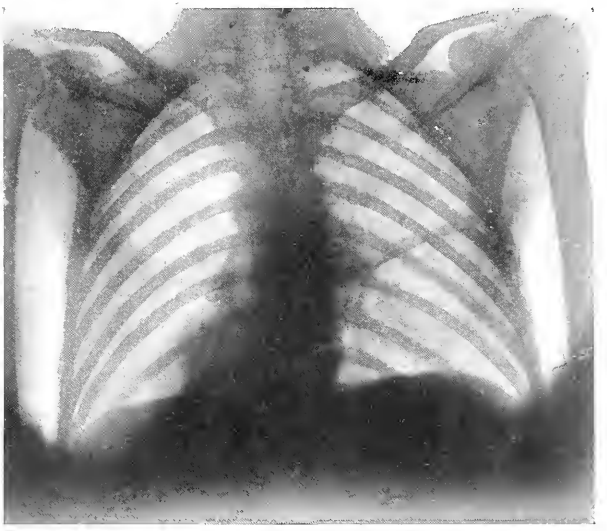
Serous diaphragmatic pleurisy.—This form is much more frequent than the preceding and much more insidious as well. It occurs most often in tuberculous cases, manifesting itself either in the course of the development of pulmonary lesions, or as a terminal process, or as a sequela of pleurisy of the large cavity.

In the greater number of cases the overlying lung will not have retained its normal transparency.

The following case was observed by Barjon clinically and radioscopically and later verified by autopsy. A man thirty-nine years of age entered the hospital during his service for pulmonary tuberculosis. On examination he showed the following signs: slight dullness of the apex and dullness of the left base; vocal fremitus was markedly increased at the apex and not present at the base. On auscultation there was heard at the apex roughened inspiration, prolonged expiration

RADIOGRAPH 4B

No. 200. E. B. Male, 37 years old. Chronic pulmonary tuberculosis. Diaphragmatic adhesions on right—middle of dome.



RADIOGRAPH 5. SCLEROSIS OF THE INTERLOBE

A tuberculous case with advanced pulmonary lesions and tuberculous peritonitis—aseitic type.

Transverse opaque band, slightly oblique from apex to base and from without inward, cuts through the center of the right hemithorax in its entire width. Besides considerable enlargement of the right hilus shadow, attached to the median shadow (tuberculosis of hilus) and diffuse shadows in both lungs, more marked and more extensive on the right (pulmonary lesions).

and râles; now and then moist explosive expiratory râles. At the base the vesicular murmur had disappeared; no sounds; no râles; no egophony; no aphonic pectoriloquy.

Radioscopic examination showed a diffuse obscurity of the whole left chest, greatest at the apex and base. Towards the apex the obscurity extended to the upper two-thirds of the chest; it was dense but not homogeneous, and in the center of the opaque zone there was distinguished a small, irregularly rounded clear area, the size of a walnut, which suggested a pulmonary cavity. At the base the obscurity was less extensive but more homogeneous and more compact. It was continuous with the shadow of the heart, occupied

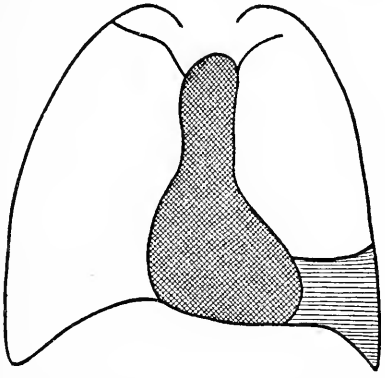


FIG. 8. LEFT DIAPHRAGMATIC PLEURISY

all the inferior external side of the hemithorax, and completely effaced the costodiaphragmatic cul-de-sac. The diaphragm was totally immobilized on this side and no respiratory movement was perceptible.

This shadow, however, did not show a clearly defined upper contour. It was gradually effaced, continuing imperceptibly with the gray tone of the lung above, almost giving the impression of a pleurisy of the large cavity in process of absorption; but the findings obtained by clinical examination did not favor this interpretation.

Autopsy showed that it was an encysted serous diaphrag-

matic pleurisy, added to extensive pulmonary tuberculous lesions, with a small cavity, as radioscopic examination had indicated.

Solid and complete obscurity of the base in tuberculous cases with effacement of the costodiaphragmatic cul-de-sac ought to be suspected, especially when on clinical examination auscultation is negative at this level. Certainly extensive pulmonary lesions of the base with a dry pleural reaction and adhesions may give a like image, but it is, however, exceptional for the obscurity to be as homogeneous and complete as when there exists at the same time an encysted effusion.

Dry diaphragmatic pleurisy, adhesions.—This form is very frequent in tuberculous cases; sometimes it is associated with very extensive adhesions or even with a total symphysis; sometimes it remains localized in the diaphragmatic region. Most often it does not give any clinical signs; sometimes a little diminution of sonority and fremitus at the base with obscurity of respiration and without râles or friction.

Radioscopy is very important in detecting dry pleurisy with adhesions, the investigation of which has become indispensable since Forlanini's method of treatment of pulmonary tuberculosis. Before resorting to artificial pneumothorax it is absolutely necessary to be informed regarding the mobility of the lung and to be sure that pleural adhesions will not prevent the needle from penetrating the pleura and will not prevent the retraction of the lung, which is indispensable for successful treatment.

The principal radioscopic signs of this localization are: immobilization and deformation of the diaphragmatic dome and the appearance of a double contour with diminution or disappearance of the costodiaphragmatic cul-de-sac.

When solid adhesions exist, the contour of the diaphragmatic dome is almost always deformed. Instead of presenting a regularly rounded convexity, the line of demarcation becomes either horizontal or oblique from top to bottom and

from without inward, or angular so that the sharp angle occupies the middle part of the deformed curve.

This deformation is accompanied usually by more or less complete immobilization, and it is not uncommon to see the respiratory movements entirely suppressed, while they persist on the opposite side. The costodiaphragmatic cul-de-sac may be completely effaced, but often it is only reduced and deformed. Finally, when the symphysis is complete, when the pleural layers are thickened or when a more or less thick exudate is formed between them, the lung becomes compressed above the diaphragm and between the pulmonary clearness and the dark contour of the arch a gray zone corresponding to this exudate is seen, which on the

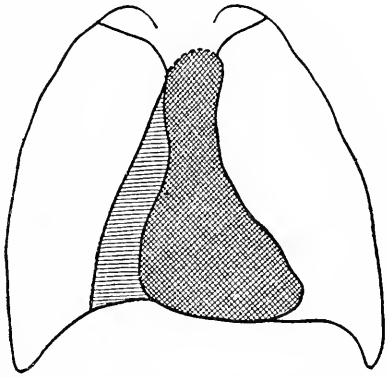


FIG. 9. RIGHT MEDIASTINAL PLEURISY

screen or the radiographic plate appears as a quite characteristic double contour. Barjon observed a case of this kind which was verified by autopsy in a chronic tuberculous patient. The radiograph of this case is given.

MEDIASTINAL PLEURISY.—Mediastinal pleurisy is rare. It may be purulent or serofibrinous. It may be dry without effusion. Of these different forms the first is much the most important and the most serious. Left to itself, it may result fatally. It necessitates, therefore, intervention, which may

be successful, provided it is not resorted to too late. It is important to make the diagnosis as early as possible.

The two other forms are less serious. They are ordinarily cured by medical means. In the dry form it is sufficient to apply a counter-irritant over the inflamed zone, without any need of exactness. In the serofibrinous form, puncture is rarely necessary; the cure is spontaneous.

Mediastinal pleurisy with effusion.—The collection may be present in the anterior or in the posterior mediastinum; it may be unilateral or bilateral. It may be combined with diaphragmatic pleurisy or with pericardial effusion.

What in general may be considered characteristic of radioscopic examination in mediastinal pleurisy is the fact

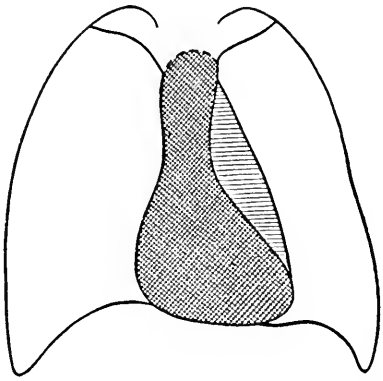


Fig. 10. LEFT MEDIASTINAL PLEURISY

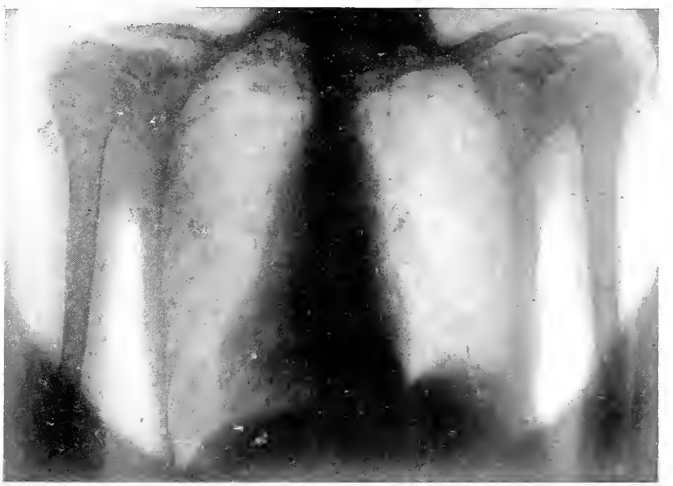
that the abnormal shadow which it reveals is always superadded to the median shadow. It deforms and increases this shadow at a point differing according to its location.

In the posterior mediastinum it is seen as a dark band adherent to the vertebral shadow and occupying all the inferior part of the thorax from the hilus of the lung to the diaphragm. In the anterior mediastinum, on the right, it is seen as an obscure triangle, the apex of which corresponds to the hilus of the lung and the base to the diaphragm; on the left, it is like an enlarged aortic shadow and surmounts that

RADIOGRAPH 6. LEFT DIAPHRAGMATIC PLEURISY IN PULMONARY TUBERCULOSIS

Diffuse shadows, scattered mottling in the right lung. More important obscurity of the upper two-thirds of the left lung with intervening clear zones (cavities). At the left base: very opaque limited shadow situated above the diaphragm, the outline of which, as well as that of the heart, is effaced. Suppression of respiratory movements.

Clinical signs: cavity indications in the upper two-thirds of the left lung; at the base flatness with absence of fremitus and obscured respiration.



RADIOGRAPH 7. DIAPHRAGMATIC DRY PLEURISY AT THE RIGHT BASE WITH ADHESIONS

Elevation and deformation of the diaphragmatic dome at the right. Double outline of the diaphragm. Complete effacement of the costodiaphragmatic sinus. Immobilization of the diaphragm.

Autopsy.—Complete diaphragmatic adhesions of the right base. Between the lung and the diaphragm the presence of a considerable depth of organized exudate corresponding to the grayish tone which surmounts the diaphragm. This explains the double contour seen on the print.

of the heart as in aneurysm of the descending portion. Such at least is the theoretical description. In reality, things are not always as clear as that, and to detect mediastinal pleurisy it is necessary to compare the clinical symptoms with the radiological indications.

Mollard and Rebattu reported a case with a purulent collection which involved the mediastinum anteriorly and posteriorly on the left side. Diagnosis was based on the following considerations: In spite of an effusion which did not seem very abundant, marked dyspnœa was present and especially a marked displacement of the heart to the right. It therefore seemed that the fluid—rare in the large cavity—was more abundant and encysted in the mediastinal region.

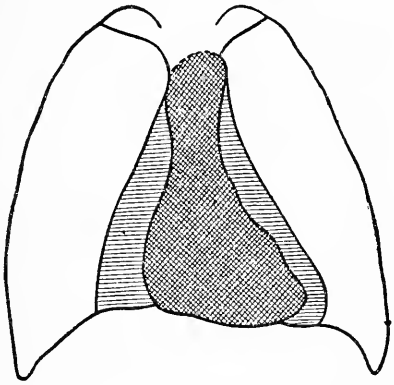


Fig. 11. PSEUDO PERICARDIAL FORM. MEDIASTINAL PLEURISY

On the other hand, radioscopic examination showed, in the middle of a general obscurity of the left hemithorax, excepting only the apex, a denser shadow visible at first in front, in contact with the compressed heart, then at the same time in front and in back in the mediastinum. A slight evacuation followed by a rather fœtid expectoration soon indicated the nature of the collection. After this series of findings diagnosis was completely and definitely made and soon verified by surgical intervention.

Devic and Savy (Revue de médecine, 1910) reported their study of mediastinal pleurisy from a very general point or view. They have, in particular, included a detailed chapter on radioscopic examination by Destot.

These authors lay down the principle that in order to make a radiological diagnosis it is not necessary to have complex cases in which total obscurity of the radioscopic pulmonary field is caused by old and extended pleurisy lesions.

The anterior forms are especially studied and distinction is made between slight and marked effusions. Slight effusions give a lightly shaded band which doubles the cardiac shadow; it is unilateral or bilateral, more frequent on the right, especially in infants. Marked effusions, usually anterior, take the pseudo-pericardial forms and are much more interesting from a radio-diagnostic point of view. The shadow shown on the screen is quite like that of pericarditis with marked effusion. It is therefore necessary to make a diagnosis between the two.

Destot points out a sign which to him seems of great value, namely, the disappearance of the heart beats in mediastinal pleurisy and, on the contrary, their preservation in pericarditis with marked effusion.

Investigators do not agree on this point. Béclère points out as a sign of pericarditis with marked effusion the diminution or the disappearance of cardiac pulsations. Destot, on the contrary, applying the physical principle of the incompressibility of fluids, admits that the beating of the heart is always visible in pericarditis alone—that is to say, when not accompanied by any pleural reaction. In support of this he cites a case of Bérard and Pehu's of pericarditis containing three liters of fluid, in which the pulsations of the cardiac shadow were clearly shown and concludes; when pericardial effusion gives no pulsation in the shadow produced, there is adjacent mediastinal pleurisy associated with pericarditis. This association is in fact quite frequent.

In cases where it would be difficult to know exactly

whether there exists or not a superadded pericarditis, Destot advises an indirect procedure by which the stomach is slightly inflated. The inferior surface of the diaphragm is then clear. If at this level an abnormal protuberance exists—a convexity under the inferior surface of the immobile diaphragm, it is concluded that a superadded pericarditis is present, for the inferior surface of the heart is not enclosed in the pleura and this convexity can be due only to an increase of pressure in the pericardium.

Dry mediastinal pleurisy.—This form does not have great interest and appears on radioscopic examination as an abnormal shadow superadded to the median shadow without form or very exact outline. It is often taken for chains of glands in the neighborhood of the hilus and gives, principally on the right, a more extensive shadow of triangular form, often difficult of interpretation.

Pleurisy of the Hilus Region. The Hilus Open Space of the Pleura.—This form of pleurisy is not well known. That is because it does not give sufficient clinical signs to attract attention because it is of very short duration. It is cured very quickly or its form changes, the purely hilus form passing most often unnoticed.

One thing only holds the attention of the radiologist and that is the existence of abnormal images localized in the region of the hilus. The interpretation of these images is impossible by radioscopy alone, but due to clinical cooperation, a reasonable explanation can be given which the development justifies.

Radioscopic examination will have accomplished much by showing the presence of these partial pleurisies, which certainly will become less rare as they become better known.

Personally, Barjon observed two cases of pleurisy of the hilus region. In one case the pleurisy remained limited, was evacuated spontaneously through the bronchi and rapidly cured. In the other case, the pleurisy, at first of the hilus, affected the interlobe secondarily, became transformed into interlobar pleurisy, and still later, affected the entire pleural

cavity. These three stages were very well followed clinically and radiologically. Recently Cade and Goyet reported (Société médicale des hôpitaux de Lyon, June, 1913) a case which ought to be added to this group; the pleurisy, at first limited to the region of the hilus, affected the interlobar cavity secondarily.

The analysis of these three cases serves to outline the clinical and radiological history of these pleurisies.

The hilus open space of the pleura.—Anatomically the region of the hilus is one of the most complex parts of the pleura. In the hilus is a sort of open space, found at the junction of all the secondary diverticula of the pleura. The large pleural cavity, the interlobes, the anterior and posterior spaces of the mediastinal pleura all end in the neighborhood of the hilus. The diaphragmatic pleura alone does not show direct connection with the open space.

This region of the hilus undergoes many changes. The hilus itself, the extremities of the pulmonary lobes, circumscribe a whole series of pleural folds, forming small grooves or small potential spaces which adhesions may easily cut off. The adjoining organs, in particular the aorta, the artery, pulmonary veins and vena cava, by the compression they exercise locally on these pleural layers may facilitate the formation of rapid adhesions on an inflamed pleura. It is easy to understand therefore that in this region small pleural diverticula may be isolated and become the seat of limited partial effusions.

Causes of infection are not wanting in this region,—the proximity of the large bronchi which bring it into direct communication with the outer air; the presence of numerous tracheo-bronchial, bronchial and hilus glands which are there for the express purpose of serving as a barrier to infections, but which may, in their turn, transmit them; finally, the œsophagus which, through its proximity may become the point of departure of disease as in the case observed by Cade and Goyet.

All these reasons explain the possibility of pleural localiza-

tions limited to the hilus region. Radioscopy and clinical methods unite in demonstrating their existence.

Case 1.—Acute febrile condition. Sudden appearance of a purulent expectoration with extremely fœtid breath. Radioscopic shadow gray, diffused, localized in the region of the right hilus. Purulent encysted pleurisy of the anterior region of the hilus. Rapid spontaneous recovery.

This patient, fifty-two years of age, was referred to Barjon by Gallavardin. Development in 3 phases.

1st phase from the 2nd to the 8th of May: malaise, slight temperature, no cough. 2nd phase from the 8th to the 11th of May: severe chills, severe stitch in the side, the temperature rose to 40° C., cough, brownish expectoration. 3rd phase beginning May 11th: sudden appearance of very fœtid breath and expectoration, undeniably purulent, abundant, without true evacuation.

Radioscopic examination.—This could only be made after spontaneous evacuation of the collection. It showed a rather extended shadow, irregular, of moderate opacity, situated in the vicinity of the right hilus. It was separated from the median shadow by a clear, narrow band and had neither exact form nor contours.

It suggested a small focus of encysted pleurisy emptying into the bronchi, or a pulmonary gangrene lesion. Radioscopy affirmed the location but gave no indication of its nature.

Clinically very localized physical signs were present in addition to the radioscopic image: slight dullness in the second intercostal space at the sternal border; percussion in this area provokes a fit of coughing with purulent expectoration; extremely fœtid breath; nothing on auscultation.

Rapid development and recovery; in four days the temperature fell again to normal; patient discharged cured on the 15th day.

Interpretation.—Rapid development, the absence of all important signs on auscultation, the sudden and simultaneous appearance of the fœtid breath and purulent expectoration, the spontaneous improvement taking place after the evacuation of the fœtid purulent collection, the definite cure obtained within a few days afterward, almost without treatment; all point in favor of a small encysted pleurisy in the region of the hilus. Only one other theory might be considered—that of a focus of pulmonary gangrene on

account of the odor. But in such a case the fœtid breath precedes expectoration, stethoscopic signs are more important, the general condition more serious, the cure is not obtained so quickly and without treatment.

Case II.—Acute febrile condition. Purulent encysted pleurisy of the anterior region of the left hilus. Secondary extension to the whole interlobe. Evacuation and slow extension to the large pleural cavity. Surgical intervention, cure.

This patient, fifty-nine years of age, had for about one month a persistent fitful cough, painful, with hoarseness. Signs of diffuse bronchitis and fever, 38.8° C.

A first radioscopic examination, June 5th, shows on the left in the region of the hilus, between the aortic arch and the heart, an opaque shadow with well defined contours, representing roughly the form of a kidney. This shadow merges below into the shadow of the heart, from which it is difficult to separate it, but on the side of the lung these contours are very clear.

Another examination on the 20th of June is quite different. In the interval the condition has become worse, the temperature has reached 39.5° C, the expectoration has become purulent and bloody. The dullness has extended under the left clavicle. Auscultation gives numerous broncho-pneumonic foci with fine râles. The radioscopic image is very different from that observed fifteen days before.

A clearly defined, very opaque shadow is present, occupying the whole middle portion of the left lung and extending from one border to the other throughout the entire width of the hemithorax. The superior and inferior borders are slightly uneven. The diagnosis of interlobar pleurisy is apparent.

There has been therefore a change from pleurisy of the hilus into interlobar pleurisy.

No intervention could be made at this stage; it was only two and a half to three months afterwards that an abundant evacuation was produced and that from the effect of rupture of adhesions in a third phase, the large pleural cavity was invaded.

A first intervention drained the large pleura; later a second intervention was necessary on the encysted interlobar focus which had not been sufficiently emptied. The patient had a perfect recovery.

The development, extension and repeated intervention confirmed the diagnosis.

In connection with these two cases of Barjon's the case of Cade and Goyet's is here included.

Case III (Cade and Goyet).—Wound of the œsophagus by a bony foreign body. Poor general condition, fever, chills, infection. Hemoptysis, purulent expectoration, then true vomica. It is a question of an encysted pleurisy.

Radioscopic examination made after the evacuation shows a light obscurity in the middle part of the left lung above the heart.

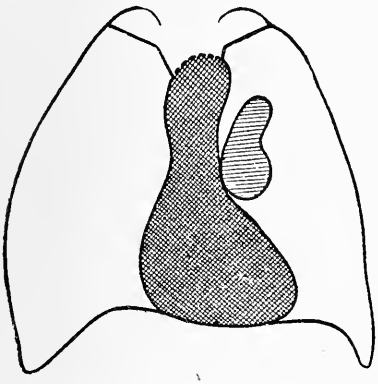


Fig. 12. HILUS PHASE

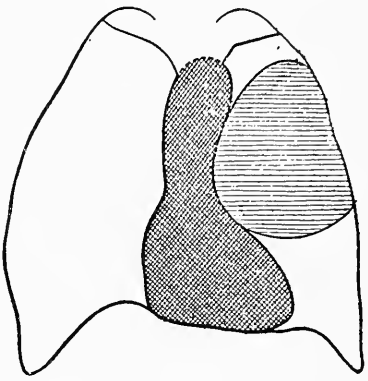


Fig. 13. INTERLOBAR PHASE.

Two phases of an interlobar pleurisy fifteen days apart.

The posterior space, on oblique examination, appears opaque in its middle portion.

Barjon thinks this case could be interpreted as an encysted pleurisy of the posterior region of the left hilus, affecting perhaps secondarily the posterior space of the mediastinal pleura.

In fact, according to radioscopic examination, neither the large pleura nor the interlobe seem to have been involved. As the evacuation was sufficiently abundant, it might be asked whether there has not been secondary involvement of the posterior mediastinal space. The image of this localization easily passes unnoticed, covered as it is by the shadow of the heart. On the other hand, the œsophageal origin of the infection would easily explain this extension.

The posterior localization of the empyema seems confirmed clinically by stethoscopic signs, friction, râles and expiratory sounds which were noticed behind in the sub-spinous fossa.

These three facts establish the pathological history of encysted pleurisy of the hilus.

Location.—Encysted empyema may develop in the region of the hilus, either on the right (Case I), or on the left (Cases II and III). It may be localized in one of the many folds of this pleural open space, at the entrance of which arise all the diverticula of the pleura.

It may be localized either in front of the hilus ("hilaire anterieur"); Cases I and II have this origin; or behind ("hilaire posterieur") as in Case III.

Origin.—It is due to an infection, the origin of which is often bronchial or glandular in the anterior location, and which may also be of œsophageal origin in the posterior location. Many other causes may intervene besides.

Development.—When early and sufficiently firm adhesions have had time to become established, empyema may remain localized in the region of the hilus, develop there and without progressing undergo resolution (Case I).

At other times the affection develops at two different places. It remains at first localized in the region of the hilus, then it may secondarily affect an adjoining space of the pleura. In Case II, anterior location, the empyema has affected the whole interlobe and the hilus pleurisy is changed into an interlobar pleurisy. In Case III, posterior location, the extension seems rather to have taken place in the posterior space of the mediastinal pleura.

The extension could have taken place just as well in the large pleural cavity, as occurred gradually in Case II, in the course of a third stage. So that pleurisy of the hilus may sometimes precede any form of pleurisy, whether total, interlobar, or mediastinal. As the true hilus phase is short and as it gives only very slight local symptoms, it may easily pass unnoticed.

Radioscopic diagnosis.—Radioscopic examination alone demonstrates these localizations. Pleurisy of the hilus is shown on the screen as limited shadows, the appearance of which differs according to whether examination was made

before or after the evacuation of the collection in the bronchi.

Before evacuation a very opaque, distinct shadow with well marked contours is shown. This is so in Case II, in which this shadow situated on the left border of the median shadow might suggest a mediastinal tumor. The second examination, showing the change into interlobar pleurisy decided the diagnosis.

After evacuation the image is less opaque, the contours less sharply defined. It is sufficient, however, to attract attention to the localization at the hilus. It would seem probable that in such a case there might be, after the evacuation, a hydroæric image suggesting partial pneumothorax. Nevertheless it is not produced either in Case I or in Case III.

It is therefore necessary that radiologists learn to discuss the interpretation of abnormal shadows of the hilus region and that a place be given to encysted pleurisy of the open space of the hilus in addition to mediastinal tumors, glandular masses, limited pulmonary lesions.

CHAPTER III

PNEUMOTHORAX

PNEUMOTHORAX occurs anatomically through the penetration of air or gas into the pleura. If adhesions do not exist between the two layers of the pleura, the gas fills the cavity, compressing the lung towards the hilus. A series of radiological images of the thorax results which have a characteristic appearance and which will be described presently.

Clinically a distinction is made by certain investigators between open pneumothorax, closed pneumothorax and valvular pneumothorax. Open pneumothorax is that in which the cavity communicates with the exterior through an intermediary bronchial fistula. Closed pneumothorax is that which has no communication with the exterior. Valvular pneumothorax would be that which shows an intermittent communication with the exterior. The fistula would in some way be closed by a valve which permits the entrance of additional quantities of air through the force of expiratory pressure, but checks its outlet. In this way, the tension of so-called valvular pneumothorax would go on increasing and would give place to serious results from suffocation. There seems to have been much criticism of this mechanism which has been proved. There is no exact information regarding the state of tension in so-called valvular pneumothorax. Netter gives as an average the following pressures:

Open pneumothorax = atmospheric pressure

Closed pneumothorax = —7 inspiration + 3 expiration

Valvular pneumothorax = —1 inspiration + 5 expiration.

Bard in his study of pressures indicates as the maximum + 8 and + 10. Barjon does not believe that higher pressures than these have been recorded. These pressures are greatly

exceeded in artificial pneumothorax, in the course of which the exact measurements attain pressures of + 15 + 18 + 22 and even, exceptionally, + 35 + 40 and + 45 (Bernard). Very marked displacement of the heart and mediastinum is found to which the patients readily accommodate themselves. These excessive pressures do not seem ever to have caused the serious results of suffocation that have been attributed to valvular pneumothorax. Bard has refuted this theory of valvular mechanism and shown that the air could not accumulate under pressure in the pleura by means of a valvular fistula. It is therefore necessary to find another cause to explain these mishaps.

So-called suffocating pneumothorax ordinarily occurs in the tuberculous; respiratory difficulties are immediate and follow the harsh penetration of a certain quantity of air into an inflamed and sensitive pleura. This air is accompanied by septic products arising from the open tuberculous lesion. An active reaction of the pleura results which provokes reflex difficulties comparable to those noticed following certain unfortunate cases of artificial pneumothorax or even of simple punctures which have caused sudden death. If the lungs are already affected by deep and extensive lesions, ifthe field of hematosis is reduced to a large extent, equilibrium is not re-established and the patient succumbs to asphyxia. This occurred in the two cases of Bouveret's (Lyon méd., 1888).

It seems indeed that the increase of pressure, which moreover has not been proved, as it has never been measured under such circumstances, ought not to be held responsible. In fact, suffocating pneumothorax remains, but valvular pneumothorax does not exist.

Radiologically no distinction can be made between these different forms of pneumothorax. It seems logical to make an etiological division and consider the two principal forms:

Spontaneous pneumothorax which is usually open.

Provoked or artificial pneumothorax which is usually closed.

Each of these forms may be total, limited or encysted ac-

cording to whether the large pleural cavity is free of adhesions or whether, on the contrary, it is divided and separated into secondary compartments.

Spontaneous Pneumothorax.—Spontaneous pneumothorax is found most often in the tuberculous. It may be produced in the course of an emphysema through rupture of a vesicle. It may follow a traumatism, a vomica of pleural origin, or may be due to quite other mechanism.

It rarely remains a true pneumothorax. In this case it resembles artificial pneumothorax, which will be described further on. It becomes complicated more or less rapidly by an effusion which may be serous, sero-hematic or purulent. The coexistence of this double effusion—gaseous and fluid—in the middle of the pleura causes the formation of quite characteristic radiological images, which will now be considered.

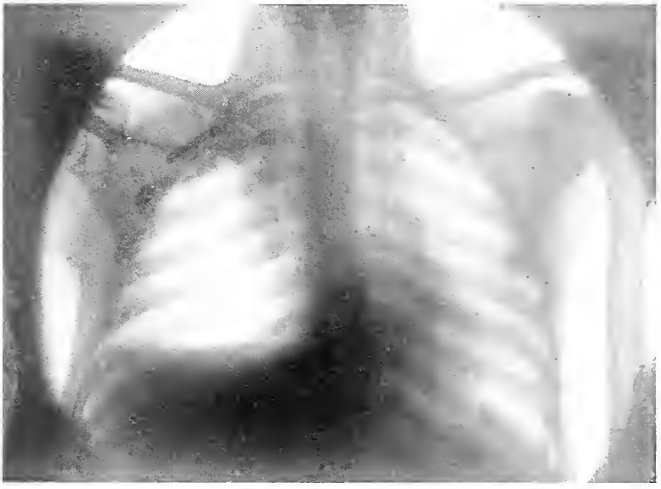
The pleural cavity appears under a very different form from that which it shows in pleurisy. In the upright position the fluid effusion, on account of its weight, occupies the lower part of the pleura; the gaseous effusion is localized in the upper part. The first presents a complete opacity; the second, a very sharp clearness. The contrast between the two is therefore striking. A perfectly clear straight, horizontal line divides them; it corresponds to the fluid surface which forms an absolutely exact line of level. The hemithorax appears then, according to the classic comparison, as a bottle half full of ink.

The mobility of the fluid surface is shown by manipulation. If the patient is inclined either to the right or left, the body of fluid is seen to be displaced on the same side while the surface remains always horizontal, the line of level perfectly straight.

If the patient is mobilized and is forcibly shaken, the fluid is seen to be actively agitated—waves appearing on its surface and striking against the walls. This is the Hippocratic succession phenomenon produced before the eyes of the observer.

RADIOGRAPH 8. ENCYSTED EMPYEMA OF THE RIGHT HILUS REGION

Extensive diffuse obscurity of the entire region of the right hilus without definite outline. The radiograph could only be made after the evacuation of the pus.



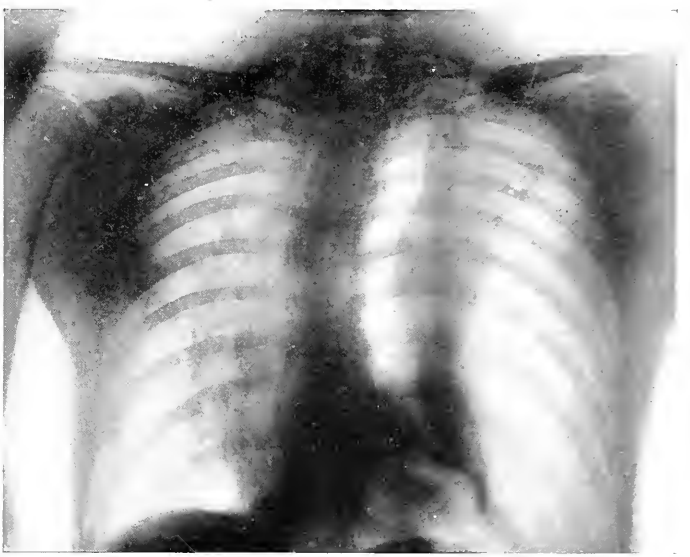
RADIOGRAPH 9. RIGHT SPONTANEOUS PYOPNEUMOTHORAX IN A TUBERCULOUS PATIENT

Pyopneumothorax with medium effusion, the line of level horizontal and mobile. The right lung retracted towards the hilus remains adherent and obscure throughout the whole region of the apex. Very appreciable displacement of the heart and mediastinum to the left. Left pulmonary lesions already very apparent; obscurity of the apex, scattered mottlings.

RADIOGRAPH 10. ARTIFICIAL PNEUMOTHORAX FOR TUBERCULOSIS OF THE RIGHT LUNG

Complete detachment of the lung except in the extreme apex. Lung retracted towards the hilus in complete collapse. Displacement of the heart and mediastinum to the left. Elongation of the right hemithorax, enlargement of intercostal spaces, lowering and flattening of the diaphragm. Movement of balance. Inspiratory displacement of the mediastinum.

Auscultation—Pneumothorax signs. Amphoric breathing, metallic tinkling, brassy sounds.



RADIOGRAPH 11. ARTIFICIAL PNEUMOTHORAX WITH INCOMPLETE DETACHMENT OF THE LEFT LUNG

The left lung has remained adherent to the apex and in the axillary region; at the base a pulmonary "tongue" has remained adherent to the diaphragm at the left of the heart.

The pneumothorax is made up of two parts,—a large lateral air chamber occupying all the side from the axilla to the diaphragm, and a small chamber situated above and inward against the vertebral column below the clavicle. Displacement of the heart and mediastinum.

During this time, the lung also has undergone marked modifications. Compressed by the double effusion—fluid and gaseous—it retracts towards the hilus, if adhesions do not prevent this movement. Its volume therefore becomes greatly reduced; it appears as a stump, the contours of which are obscured by the fluid effusion but appear clearly in the gaseous zone. In fact, the compressed lung, having retracted, is emptied in large part, if not totally, of the air that it contained. Its parenchyma is, so to speak, condensed; it has become much less transparent and its image appears distinctly on the clear background of the gaseous pocket.

When the pneumothorax is total, when no adhesions remain, the lung appears as a longitudinal band, which is more or less broad and joins the median shadow. But adhesions modify this image infinitely—the lung may be fixed either at the apex, laterally, or at the base, and in each case a new image is shown.

All these modifications of the intra-thoracic equilibrium necessarily influence the walls of the thoracic cavity, but more particularly those which, like the mediastinum and the diaphragm, have a certain mobility.

The mediastinum is usually pushed over to the healthy side and the heart is involved in this displacement in a degree depending on the amount of the fluid effusion or the state of tension of the gaseous effusion.

But this displacement of the mediastinum is not the only phenomenon that is observed. Often, it is true, the mediastinum is immobile, but sometimes it is stimulated by rhythmic movements which certain authors have described as the "mouvement pendulaire" of the mediastinum.

This movement consists of an inspiratory displacement of the mediastinum which occurs on the side of the pneumothorax. It only occurs under certain conditions which will be studied later on. At times it is barely perceptible, at other times very accentuated and apparent; very often it is lacking altogether.

The diaphragm, which plays an important rôle in all that

pertains to respiratory phenomena, shows modifications still more noticeable than those of the mediastinum. Like it, it is greatly affected, as much from the static as from the dynamic point of view.

Its form undergoes serious variations. Its convexity gradually disappears; the muscle flattens; at the same time it is lowered and presents the form of an oblique line from top to bottom and from within outward. There results an elongation of the hemithorax in relation to the opposite side and the disappearance of the costodiaphragmatic sinus, which loses its crescent form.

The movements are also markedly modified, and in a very variable manner, according to the case. Sometimes a simple diminution of the amplitude of the respiratory movements is seen, sometimes a retardation of these movements, sometimes both at the same time.

Sometimes an absolute immobilization is noted and in certain cases, where all active movement has ceased, passive movements are seen communicated through the disturbance of the cardiac contractions, especially when the pneumothorax occurs on the left side.

The coexistence of active and passive movements may also be observed. The diaphragm continues to contract in a certain measure but it is more disturbed by the cardiac beats. In that case the cardiac beats are especially felt during expiration, as the diaphragm is still sufficiently extended on inspiration to resist the disturbance from the cardiac contractions.

But certainly the most curious phenomenon that one observes on the part of the diaphragm is that which has been described as the "paradoxical phenomenon of Kienbach" or "movement of balance." This phenomenon consists in the loss of co-ordination of the contractions in the two halves of the diaphragm. In the normal state the diaphragm contracts at the same time on the right and on the left; the two arches are lowered co-ordinately and are elevated together. They might be compared to two pistons actuated by the same movement in twin cylinders.

In the course of certain cases of pneumothorax the dissociation of this movement is seen. While the diaphragm is lowered on the healthy side, it is raised on the side of the pneumothorax and inversely. The two arches act like the two trays of a balance. They might be likened to two pistons moved by an alternate movement in two paired cylinders.

Several explanations have been given for this phenomenon. Three principal theories have been set forth:

1st: Paralysis of the diaphragm on the side affected.

2nd: Thoracic aspiration.

3rd: Flattening of the diaphragm either by the positive pressure of the gas, or by the pressure of the effusion.

Each one assumes to give the sole explanation of the phenomenon. The phenomenon appears more complex and if much has been said of the diaphragm, not enough has been said of the lung. The actual practice of artificial pneumothorax corresponds to a true experimental study of this phenomenon, the conditions of the appearance of which may be studied in detail.

Theory of paralysis of the diaphragm.—This is admitted by V. Muralt and Deneke and to which Béclère agrees. Conforming to the law of Stokes, the diaphragm has lost its contractility on the side of the pneumothorax; it is no longer anything more than an inert membrane easily affected by the differences in pressure. On inspiration the diaphragm on the normal side contracts and is lowered and from this an increase of the abdominal tension results which is transmitted in all directions and raises the diaphragm on the opposite side, which no longer offers any resistance.

This theory is true in large part, but the paralysis of the diaphragm is not wholly responsible; it is only one of the important elements in the phenomenon.

Theory of thoracic aspiration.—This has been sustained by Bittorf and by Wellmann. According to these authors the thoracic aspiration is compensated on the normal side by the penetration of air into the lung. On the side of the

pneumothorax the absence of penetration of air creates a negative pressure which aspirates the diaphragm and produces its elevation while it is lowered on the normal side.

This theory, which is founded on a sound basis, is not opposed to the preceding; on the contrary, it adds to it, since the two forces are acting in the same direction; the first forces the diaphragm upward while the other compresses it downward; they act together with the same result. On the contrary, this theory, which has for its point of departure a negative pressure, seems to be opposed absolutely a priori to the following which has for its basis a positive pressure.

Theory of flattening of the diaphragm, either through positive pressure of gas (Maingot), or by the pressure of effusion (Bernard). This theory is especially defended by Maingot. Rist and Bernard identify themselves with it. It is open to discussion. It is easy to see how the condition is brought about in the course of artificial pneumothorax. Barjon and P. Courmont have studied this.

First, it is quite certain that there may be found in the pleura very strong pressures ($+10+15$ and even $+28+31$ in one case) without there being any flattening of the diaphragm; and that this complete flattening may be seen with much less pressure ($+4+6$ in another case).

It is just as evident that the "movement of balance" is lacking in a great number of cases of pneumothorax with very positive pressure. Something else is therefore the cause. Barjon has established these facts many times but four cases only of pneumothorax studied with P. Courmont will be quoted, indicating the pressure in the course of the successive interventions.

These four observations were selected especially because they represent perfectly the different stages of detachment and the increasing progress of pulmonary collapse.

Case I.—Detachment very limited. No balance movement in spite of very positive pressure. Pneumothorax, so to say, does not exist.

1st. Mrs. Da . . . in the course of three successive inflations presented the following pressures:

1.	inflation	+ 5	inspiration	+ 8	expiration
2.	"	+ 4	"	+ 10	"
3.	"	+ 10	"	+ 14	"

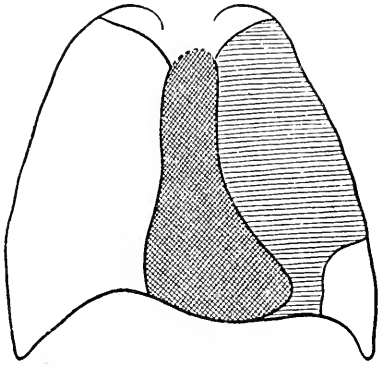


Fig. 14. ARTIFICIAL PNEUMOTHORAX, LEFT SIDE

Incomplete detachment of the lung. Very small gaseous pocket at the base. No balance.

2nd. Mr. L . . . in the course of 6 successive inflations:

1.	inflation	+ 1½	inspiration	+ 7	expiration
2.	"	+ 3	"	+ 7	"
3.	"	+ 1	"	+ 2	"
4.	"	− 3	"	+ 3	"
5.	"	+ 4	"	+ 8	"
6.	"	+ 28	"	+ 31	"

Incomplete but rather extensive detachment, occupying all the base and all the lateral side as far as under the clavicle. Adhesion of the apex. No balance in spite of strong pressures.

Case II.—Detachment very extensive but the entire apex remains adherent; no balance movement in spite of very positive pressures reaching + 28 and + 31.

3rd. Mr. Du . . . in the course of 6 successive inflations:

1.	inflation	+ ½	inspiration	+ 3	expiration
2.	"	+ 3	"	+ 9	"
3.	"	+ 9	"	+ 15	"
4.	"	+ 9	"	+ 13	"
5.	"	+ 14	"	+ 19	"
6.	"	+ 11	"	+ 15	"

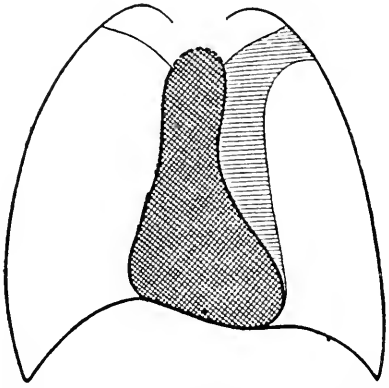


Fig. 15. ARTIFICIAL PNEUMOTHORAX, LEFT SIDE

Very important instantaneous pulmonary detachment, collapse being completed gradually. The movement of balance appears only after the 5th inflation even though there were very positive pressures from the 3rd and 4th inflations.

4th. Mr. C . . ., perfect detachment; complete collapse of the lung, presenting at the same time the movement of balance of the diaphragm and the pendulum movement of the mediastinum, even with rather low pressures, + 4 inspiration and + 6 expiration measured before an inflation. At this point the phenomenon is very much accentuated. A new inflation is made which increases the pressure to + 12 inspiration and + 15 expiration; on radioscopic examination

the movement of balance and also the pendulum movement are very much less apparent; the increase of pressure has much diminished their extent.

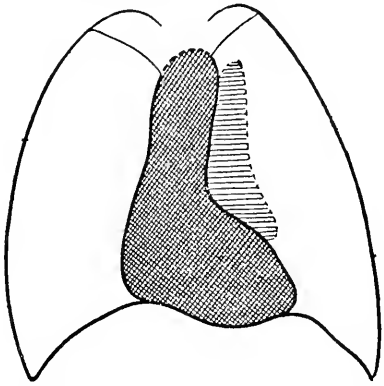


Fig. 16. ARTIFICIAL PNEUMOTHORAX, LEFT SIDE

Case III.—Progressive total detachment. The balance movement appears only after the 5th inflation when pulmonary collapse is complete.

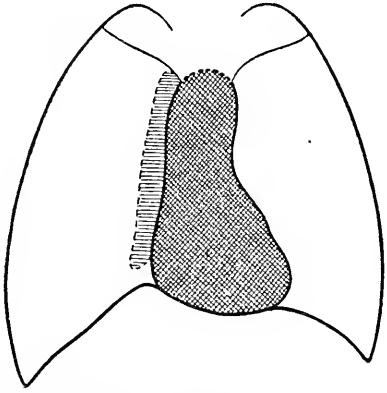


Fig. 17. ARTIFICIAL PNEUMOTHORAX, RIGHT SIDE

Case IV.—Complete detachment and total pulmonary collapse. The balance movement exists with low positive pressures + 4 + 6; it diminishes with higher pressures + 12 + 15.

Examination of these four cases shows that very often the phenomenon of balance is lacking even with very positive pressures of + 28 and + 31 in Case 2. Case 3 alone would seem favorable to the influence of pressure since the phenomenon is seen to appear after the 5th inflation when the pressure attains its maximum, but it is also at this point that the pulmonary collapse is complete; and before it was sufficiently advanced even with very positive pressures of + 9 and + 15, the movement of balance did not exist. However, Case 4 would tend to demonstrate the contrary since the phenomenon is observed at a maximum with a low pressure, + 4 + 6, and since it diminishes perceptibly with a higher pressure, + 12 + 15. It might be said, therefore, that in this case the phenomenon is observed in spite of a high pressure. In spontaneous pneumothorax the pressures are always much lower and yet under these conditions marked movements of balance are always found. It is not necessary therefore to have a high pressure to produce them.*

In pneumothorax accompanied by effusion it is a question whether the weight of the effusion could replace the tension of the gas by acting directly on the diaphragm. Some investigators have thought so.

The observation demonstrates that if the movement of balance exists in pneumothorax with slight effusion, it is scarcely ever found with large effusion, which, however, acts on the diaphragm with considerable pressure.

It seems therefore that it might be said that the movement of balance of the diaphragm may be observed in spite

* Barjon examined, through courtesy of Dr. Dumarest, a series of fourteen cases of pneumothorax at the Mangini Sanatorium. All these cases had positive pressure; the balance movement, however, was found in only one-half the cases. The case which had at the same time the balance movement and the pendulum movement most marked, had only a medium pressure of + 4.

With P. Courmont, Barjon saw a splendid balance movement in a woman where pressure reached only — 6 + 2 and in forced inspiration fell to — 6 + 0.

of a slight effusion, but a large effusion rather prevents it from being produced.

Does the pressure signify anything? What rôle has it in the production of the phenomenon?

The rôle of pressure has a certain value, but it does not act except when combined with other necessary conditions; it is not even necessary that the pressure be very high. A pressure although very high is not sufficient alone to stimulate the paradoxical movement of the diaphragm if the other conditions are not fulfilled.

The mechanism of the movement of balance appears therefore as rather complex and this would explain its relative rarity in pneumothorax. It is often lacking, in fact, and Barjon estimates that it is only met with in about 40 out of 100 cases.

This phenomenon would seem to result from a kind of unstable equilibrium established on both sides of an inert floating membrane, very sensitive to the slightest variations—the diaphragm in this particular case.

Barjon believes that the same conditions might be applied to the mediastinum and might serve to explain also the inspiratory pendulum movement which is not more frequent than the movement of balance and which often coexists with it, which seems to indicate that they obey very much the same laws.

The first condition to be realized therefore is the inertia and the absolute freedom of the diaphragm.

The inertia is obtained by the muscular paralysis conforming to the law of Stokes under the influence of the irritation provoked by the penetration of gas into the pleura, but also, and especially, by the gradual suppression of the respiratory function of the lung under the influence of its progressive collapse. The diaphragmatic respiration is effected by a reflex stimulated by the lung. While the lung remains in contact with the diaphragm, the reflex functions normally, owing to the stimulation by the lung. When the contact becomes less extensive and less perfect, the

reflex diminishes; it ceases when the separation has become complete. There is no doubt that this is one of the principal factors in inertia of the diaphragm.

The freedom of the diaphragm is dependent on the total absence of adhesions; in fact, the movement of balance is never produced with an adherent diaphragm.

The forces which act on a diaphragm in this condition are of two kinds and are as follows: abdominal pressure which forces it downward, and thoracic aspiration which draws it upward. There is nothing to be said as to abdominal pressure, it explains itself. It is the inspiratory lowering of the opposite diaphragm which breaks the equilibrium and raises the other side of the diaphragm which has become inert.

This thoracic aspiration is the result of the inspiratory increase in the diameters of the thorax. On the normal side this force is compensated for by the entrance of air into the lung. On the side of the pneumothorax, the respiration being suppressed and no air being admitted to the empty space, aspiration acts on the walls, particularly on the diaphragm and on the mediastinum, which are drawn in. The principal condition of thoracic aspiration is therefore the suppression of the respiratory function of the lungs.

This implies the complete collapse of the lung. When adhesions keep an important portion of the lung stretched, it does not collapse, inspiration persists; the thoracic aspiration is diminished or suppressed. This explains why the movement of balance is never found in incomplete pneumothorax even when the adhesions are limited to the region of the apex and when the diaphragm is not involved. In this case even a very high pressure never suppresses the pulmonary respiration and the movement of balance does not appear. This shows the importance of the part of the lungs in producing this phenomenon.

If the lung is not adherent, if it is retracted towards the hilus, then the part of pressure appears, which must main-

tain the pulmonary collapse and prevent the air from penetrating. It is only necessary that the pressure remain somewhat high, provided, however, that it is always higher than, or equal to, the atmospheric pressure. Too high a pressure under these conditions would only diminish or hinder the movement of balance, on the one hand, by diminishing the thoracic aspiration, on the other hand, by opposing the upward movement of the diaphragm. This is what was noted in Case 4. But under the same conditions a negative pressure, by diminishing the pulmonary collapse, opposes the production of the movement. In this sense it might be said that an additional inflation, by transforming the negative into a positive pressure would cause the phenomenon to reappear.

The essential conditions for the production of the phenomenon of balance might therefore be stated thus: absolute inertia of the diaphragm with absence of all adhesions; as complete suppression as possible of the respiratory function of the lungs, brought about by its total collapse; the maintenance of a moderate positive pressure.

By replacing in the above statement the word "diaphragm" with the word "mediastinum," we shall find the essential conditions which are present in producing the inspiratory pendulum movement. Inertia of the mediastinum and absence of adhesions are equally necessary; the pressure on the mediastinum is brought about by the penetration of air into the normal lung, its traction by the thoracic aspiration on the opposite side.

If only one of these conditions is lacking, the phenomenon is not produced and that explains its absence in so great a number of cases of pneumothorax.

In complete and absolute pneumothorax the two phenomena may be seen at the same time: movement of balance of the diaphragm and inspiratory pendulum movement of the mediastinum. Sometimes they are dissociated. Barjon has seen a case of pneumothorax with slight effusion show a fine movement of balance; the pendulum movement was lacking

on account of some adhesions which immobilized the mediastinum. Inversely, in a patient in whom the apex was completely detached, there was seen a very good and limited pendulum movement in the superior mediastinum, some adhesions towards the base immobilizing at the time the inferior portion of the mediastinum and the diaphragm. Very often neither one of these movements is observed.

In summing up, the images which appear on the screen in the study of pneumothorax show a characteristic appearance not found in any other thoracic affection.

The radioscopic examination is therefore very characteristic and plays a most important rôle in the study of pneumothorax. This examination is indispensable in making diagnosis. It is limited to confirming it when the affection has already been diagnosed by the clinician, who has determined the usual stethoscopic signs of pneumothorax by examination of the patient: amphoric breathing, metallic tinkling, brassy sounds, Hippocratic succession, etc. But the extent of the pneumothorax and especially the condition of the lung are better determined by radiological examination than by auscultation.

On the other hand, the so-called silent cases of pneumothorax are no longer considered, and the complete absence of all positive signs on auscultation makes them impossible to detect except by radioscopic examination, which alone is capable of demonstrating them.

Limited or encysted pneumothorax.—This type of pneumothorax is produced in a pleura divided off by adhesions and involves only a limited part of the pleura. It may be of pulmonary origin in certain tuberculous cases; it may be of pleural origin when it follows an encysted pleurisy—an interlobar pleurisy, for example.

Since it is much more limited than total pneumothorax, it is more silent from the clinical point of view and very often shows no sign. Radioscopic examination alone indicates its presence. Ordinarily it is seen on the screen as a limited hydroæric image, with the surface of the fluid level mobile

and changing. Hippocratic succussion exists when the quantity of fluid is sufficient, but the greater number of the other signs already described are lacking: the cavity being most often connected neither with the diaphragm nor the mediastinum, the necessary conditions for producing the movement of balance and the pendulum movement are completely lacking. The image is, however, sufficiently characteristic to attract attention.

Barjon had occasion to follow for several weeks a patient with partial pneumothorax that never gave any stethoscopic sign. He watched its progressive retrogression, its disappearance and definite cure without intervention.

Diagnosis is sometimes difficult in the case of a pulmonary cavity when it presents rather large dimensions and contains a certain quantity of fluid. Barjon had a tuberculous case in whom the radioscopic image suggested a partial pneumothorax, but autopsy showed a large cavity. In such cases there is no certain indication for making diagnosis. When cavities are smaller, they are often multiple; they contain only a little fluid; often in a very intermittent manner, they empty and fill from day to day; their edges are more opaque, the surrounding pulmonary tissue being more condensed, but when they show these characteristics, they scarcely ever are confused with a limited pneumothorax.

In another case (although rare) Barjon observed with P. Courmont a thoracic hernia of the stomach through the diaphragm. The diagnosis was complicated by the intrathoracic stomach being perforated at the site of an old ulcer and this perforation had brought about the development of a true pyopneumothorax of the large cavity. There were, therefore, two superimposed hydroæric cavities. The inferior one was the herniated stomach which had become thoracic with its fluid contents, its air chamber, its mobile fluid level; the superior was the true pyopneumothorax of the large cavity. It gave the illusion of a double pneumothorax, the inferior appearing partial and the superior total. Autopsy gave the explanation of this curious picture.

Double pneumothorax.—Cases of this type may be compared with certain radioscopic images of pneumothorax with fluid effusion showing the presence of two lines of fluid level distinct and superimposed.

This particular appearance is explained in the following way. It is a pneumothorax developed in a pleural cavity showing some adhesions or slight diverticula above the level of the effusion. When the patient lies in the dorsal, ventral, or lateral decubitus, a small amount of fluid may

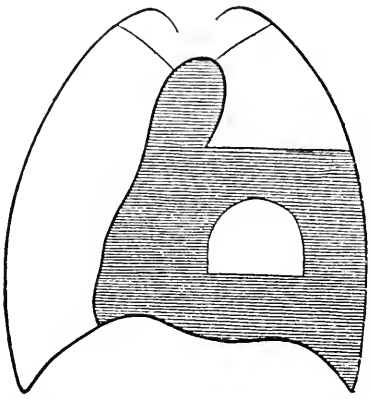


FIG. 18. THORACIC HERNIA OF THE STOMACH, GASTRIC PERFORATION, SECONDARY DEVELOPMENT OF A PYOPNEUMOTHORAX OF THE LARGE CAVITY

filter towards these adhesions and penetrate the diverticula. If the patient is raised up quickly, the fluid may be retained in these diverticula, where it forms small pool-like areas with a movable level of fluid, which give the appearance of a second independent pneumothorax.

ARTIFICIAL PNEUMOTHORAX.—Radiological examination is indispensable in artificial pneumothorax. Without it this method of treatment would be practically inapplicable.

Introduced into practice by Forlanini, this new therapeutic measure met with success and unfortunately with some serious results which awoke the instinctive distrust of phy-

sicians. It was necessary to make it more exact regarding indications and contra-indications, more careful in intervention, and more reserved in after treatment.

The physician proposing intervention by artificial pneumothorax in a tuberculous patient will ask the radiologist two principal questions: 1. Is pneumothorax indicated? 2. Is it possible?

The indications or contra-indications for intervention are obtained clinically and from the development of the pulmonary lesion, the general condition of the patient, the functioning of the cardio-vascular system, the presence or absence of all other tuberculous manifestation. All this becomes part of the clinical examination.

But there is another point of extreme importance on which the radiologist must give advice:—the extent of the lesions, whether they are unilateral or bilateral.

The unilateral occurrence of lesions has been rightly considered a very important condition. It is evident that the one lung which remains in a functioning condition must be capable of hematosis. Radioscopic examination is therefore very important because it indicates the condition of transparency of the lung. To be of the greatest value the clinical and radioscopic examinations must be in accord. If auscultation is negative and the screen indicates a normal transparency of the lung, it may be concluded that intervention is possible. If the radioscope shows abnormal shadows which are added to evident stethoscopic signs, the contra-indication is decisive.

If there is a disagreement between the two methods of diagnosis, the case must be discussed. 1st case. The radioscope shows a clear lung but auscultation reveals the existence of signs by no means doubtful; an early lesion may be suspected, still very questionable but with a progressive tendency; it is a question whether intervention, by stimulating the functioning of the lung may not aggravate the lesions and make the condition worse. It is preferable not to attempt it.

2d case. The radioscope shows one or several abnormal

shadows but careful auscultation of these areas does not reveal any suspicious sound; it may be old cicatrized lesions without any progressive tendency which are not a contra-indication to pneumothorax.

In all patients in whom there is a question of intervention by artificial pneumothorax, careful radioscopy is indispensable.

The second question, whether pneumothorax is possible, is more difficult. In the first case the question concerns the lung; in the second, the pleura.

Nothing is more difficult clinically than to know whether or not there are pleuro-pulmonary adhesions; and to recognize their topography, their extent, their firmness. It may be claimed that exploration of the thorax by the usual means: palpation, percussion, auscultation cannot always furnish exact information in this respect. Radioscopic examination has been much depended on to complete this. It must be acknowledged that it has done this only in a slight measure. Without doubt it gives better results than those obtained clinically; at least, it gives probable signs, if it does not give certainty.

Radioscopic examination is, however, indispensable from this point of view. By showing the topography of the pulmonary lesions, it furnishes indications of the probable location of the points of adhesion and their extent. It gives information on the condition of the base, on the appearance of the costodiaphragmatic sinus, in the vicinity of which the puncture is usually made, and on the extent of the respiratory excursion of the diaphragm and the mobility of its movements.

When the costodiaphragmatic sinus has retained its crescent form, when it has kept all its depth and transparency, when, at the same time, the diaphragm has lost neither the regularity of its contour or mobility, when the amplitude of its displacement has not been at all diminished, it is almost certain that there are no pleural adhesions, at least in the diaphragmatic region.

Inversely, complete effacement of the sinus with total obscurity of its inferior angle, disappearance of the contour of the diaphragmatic arch with immobilization, suppression of the respiratory movements indicate almost certainly the existence of a symphysis of the diaphragmatic pleura.

But between these two extreme aspects, a whole series of intermediary images exists, the significance of which is much less definite.

Usually when a reduction of the depth of the sinus is established, a deformation of the diaphragmatic curve and an appreciable diminution in the extent of the respiratory movements, the probability is that adhesions exist, sometimes slight, sometimes firm and extensive although the base has retained all its clearness.

In other cases even with a very noticeable obscurity added to the preceding signs, no adhesions are present and the pneumothorax will be perfectly successful.

It ought to be understood that a purely pulmonary process, if sufficiently extensive, is enough in itself to obscure the base, to diminish the respiratory movements of the diaphragm almost to suppression, to reduce in large measure the extent of the costodiaphragmatic sinus and all this without there being any adhesions.

Experience shows that in certain cases pulmonary detachment is very good although the radioscopic picture suggested the existence of adhesions; while in other cases where cure has been confidently undertaken, it is impossible to obtain a result on account of the existence of very extensive adhesions which on examination were not suspected. It is therefore impossible to make an absolute statement.

After an attempt at artificial pneumothorax another careful radioscopic examination should be made which will then give definite information. It will show immediately whether the attempt has been successful or not and the operator will know very quickly whether he ought to follow up this treatment or abandon it.

Radioscopic examination during treatment—When arti-

ficial pneumothorax has been undertaken, it is necessary to make a number of radioscopic examinations before and after each additional inflation and even in the interval if it is possible.

Immediately after the first inflation the patient ought to be examined, and this examination is the most important of all because it gives at once a general idea of what may be expected.

When after the first inflation an important detachment is seen and a large air chamber is produced, this may be considered a good sign for favorable prognosis. It is probable that the detachment will be completed gradually during successive interventions and finally a more or less complete collapse of the lung will be obtained.

On the other hand, when the first inflation has not produced any detachment, when no accumulated air chamber is found, but only some diffuse pool-like areas, or even an obscurity as extensive as before, one may fear a bad prognosis. There are certainly diffuse, extensive adhesions which will prevent all important detachment and the pneumothorax is certain to fail. The careful operator will stop after this attempt, the more persistent will again attempt one or two additional inflations, but usually they will have a good deal of difficulty in the second attempt, still more in the third, and finally will be obliged to stop.

This is the most important part of radioscopic examination, namely, the selection of cases which ought to be followed up and those which ought to be abandoned.

No other method of examination for selection of cases is as decisive. There is often an illusion of success; often into the adherent pleura large quantities of nitrogen gas are passed without effort or excessive pressure, 500 to 1000 cubic centimeters (Barjon has even seen 2 liters used in one case). Radioscopic examination alone can show that there was no such extensive detachment as was thought.

It is a question in these cases of what becomes of these large quantities of nitrogen gas. It is probable that it filters

through a loose net-work of adhesions as if through the meshes of a large net, and that it is rapidly absorbed, for the pressure drops quite rapidly in these cases. In all cases extensive and persistent detachment is not produced. If the bubbles of gas, passing through the meshes, detach them temporarily, these adhesions apparently become speedily adherent again and still more firmly, as if under the influence of a local reaction, which explains why the subsequent attempts become more and more difficult (P. Courmont).

When pneumothorax appears indicated, the attempt should be carefully made and radioscopic examination seems the best way to secure information, for it indicates at once the process which it is best to follow.

In cases where pneumothorax is at once sufficiently successful to merit its being continued, radioscopic examination will follow its progress. The adhesions which had resisted the first inflations will gradually be seen to give way and pulmonary collapse will be complete. The best results can be hoped for in these cases.

The lung is reduced to a narrow median band; all respiration is suppressed; the organ is completely passive.

The thorax is uniformly clear; its dimensions are increased through the lowering of the diaphragm; the displacement of the heart and mediastinum is at times considerable.

The heart is stimulated by rapid pulsations which are communicated in a certain degree to the diaphragm and mediastinum and these, on the other hand, are also stimulated by the particular movements already studied—the inspiratory pendulum movement of the mediastinum, paradoxical movement of the diaphragm. This is seen in total and complete pneumothorax.

But often the result is less satisfactory. The detachment, although extensive, is not complete; an important portion of the lung remains adherent, sometimes the entire apex, sometimes a part of the base, or again, the middle portion between the two air chambers, one superior, the other inferior.

These are the cases of incomplete pneumothorax in which the radioscope alone can furnish any information as to their form. The results are less striking and less satisfactory, but in these cases of incomplete pneumothorax radioscopy would not be valueless, however, and in a certain number of cases would have a beneficial effect by observing the development of the disease (Dumarest).

Many patients in the course of treatment have complications which can be followed by the radioscope. They consist of congestive attacks on the opposite side where the lung showed in reality more serious lesions than those suspected. They consist especially of pleural effusions on the side of the pneumothorax; either infection has occurred during an intervention (lung puncture, lack of asepsis), or an autoinfection of the pleura has been brought about through a series of pre-existing superficial subpleural lesions. These effusions, at first serofibrinous often become purulent. It is important to follow their development—their increase and retrogression—to find a possible indication for puncture.

All of these divers occurrences lower the percentage of favorable results in the few cases of pneumothorax which have been done. It is, therefore, necessary to be very cautious in passing judgment on a method where definite good results are still the exception.

In summing up, radiological examination applied to the study of artificial pneumothorax is very important. It assists in determining the indications and contra-indications for this method, which on the whole is applicable only to a very limited number of tuberculous cases, especially in hospital centers where patients enter in an advanced state. Bernard and Laennec in 628 patients found indications only 22 times and in only 6 was the pneumothorax successful and continued, making a little less than one per cent.

The main function of the radioscope, once the treatment has been undertaken, consists in pointing out the favorable cases which ought to be followed up and the unfavorable ones where extensive adhesions are bound to cause failure.

PART III

RADIOLOGICAL STUDY OF THE BRONCHI

CHAPTER I

FOREIGN BODIES IN THE BRONCHI

THE entrance into the bronchi of foreign bodies of small size is rather frequent. It is very important to be able to determine their presence, to mark their exact location, for in spite of the apparent toleration of the bronchial tubes, there is some danger in letting them remain too long.

Two methods of exploration are at the physician's disposal: bronchoscopy and radioscopy. Both are complete and very well tried out and it is interesting to use them together.

Radioscopic examination being more simple and less painful ought to be made first; it furnishes general information which may be of use later in bronchoscopic examination.

Nature of foreign bodies.—Foreign bodies may vary greatly and it is impossible to foresee all those which may by chance get into the bronchi. Radiologically they may be divided into two main classes: metallic and non-metallic bodies, the first being ordinarily quite easy to see, the second remaining often invisible. To the first class belong pins, which are by far the most common.

Barjon has also found a piece of a metal hook, a copper eyelet, a mouthpiece of a trumpet, a small tip of a tracheotomy tube. Garel has seen a cuff button and a nail.

Among the second class, food particles especially are found. In one case of Barjon's it was a pea. These foreign bodies are absolutely invisible on radioscopic examination and bronchoscopy must be employed in such a case and always when fluoroscopic examination is negative.

Between these two classes of foreign bodies, there are also found fragments of bone which sometimes may be visible but which very often are not, as usually the frag-

ments are very small and thin. DeBannes has published an interesting case of this kind in which the foreign body had caused a small suppurative focus.

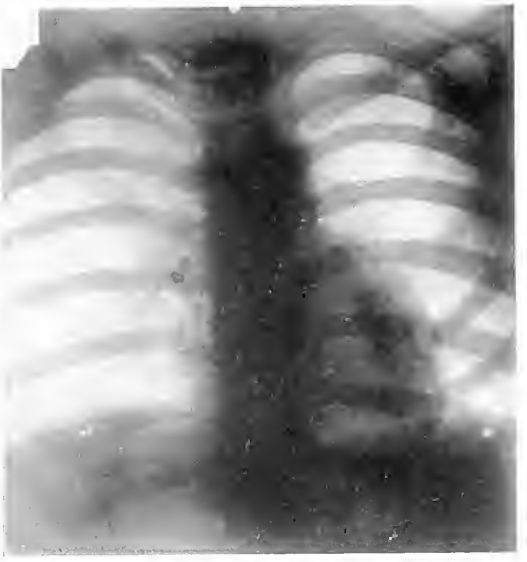
Location of foreign bodies.—Most often foreign bodies lodge in the right bronchus. The right bronchus is wider than the left, has a more vertical direction and is a more direct continuation of the trachea. At times they penetrate rather far as in the case of Barjon's where it reached the third bifurcation of the bronchus, as was confirmed by bronchoscopy. Sometimes, however, they enter the left bronchus and become fixed.

Visibility.—Metallic bodies are very clearly visible, especially if they are rather thick as pieces of tube or a mouthpiece of a trumpet. A pin is less visible and the image must be carefully studied.

In the frontal examination (which is the preferable position for this study), it will be found on the edge of the median shadow and extending a little way beyond. If it is a glass-headed pin, the head and the shank are quite easily distinguished; the head usually points downward, the point upward.

To see well one should have absolute darkness and become accustomed to it for a long time; the patient must be completely immobilized and a diaphragm should be used to examine in detail the hilus region on both sides. When the body foreign has been discovered, a new examination should be made in the dorsal position and also in the different oblique positions and an attempt should be made to locate it again. In this way its presence will be confirmed and all that remains to do is to make a radiograph in the position which has appeared most favorable, usually the frontal position.

Mobility.—When foreign bodies have remained a certain time in the bronchi they become fixed, embedded and covered by the ulcerated mucous membrane. In the beginning, during the first days after penetration, the foreign bodies are often entirely mobile. An attack of coughing



RADIOGRAPH 12. METALLIC MOUTHPIECE OF A TRUMPET IN THE RIGHT BRONCHUS

The foreign body stands out clearly in the right bronchus between the shadow of the hilus and that of the right auricle.

RADIOGRAPH 13. GLASS HEADED STEEL PIN IN THE LEFT BRONCHUS

The pin is lodged in the left bronchus. Image is found located between the fifth and sixth ribs, posteriorly; the head below at the sixth rib, the point upward at the insertion of the fifth. The shadows of the base of the heart and the pulmonary artery cover the foreign body and make it less visible.

is enough to displace them and consequently attempts at bronchoscopic examination not followed by extraction make them extremely mobilizable. Barjon has seen a glass-headed steel pin which he located in the right bronchus pass into the left bronchus, where it was found again by Arcelin some days afterwards, and again pass back into the right bronchus. He also saw another pin and a mouth-piece of a trumpet which were mobilized in such a way after bronchoscopy that they were brought up as far as the pharynx where they were swallowed and finally eliminated in the natural way.

Bronchoscopy ought therefore always to be tried, for if the first attempt at extraction does not succeed, it may at times cause sufficient mobilization to produce a natural expulsion of the foreign body.

Tolerance and infection.—The bronchi appear rather tolerant to foreign bodies. At the time of entrance there is usually produced a very acute reaction, fit of coughing and suffocation. But this soon quiets down and no functional disturbance is manifest.

Zimmern, Tuchini and Bernard, and later Chilaïditi have demonstrated that a very large amount of bismuth paste might accidentally enter the bronchi without any great harm. Yet under similar circumstances a patient of Desternes died immediately from asphyxia.

In fact, too much confidence must not be placed in this apparent tolerance, and it is always dangerous to leave foreign bodies in the bronchi. That is why definite search must be made. Infection and broncho-pneumonia are to be feared with a bronchial foreign body. Barjon has often seen patients with fever and bronchitis two or three weeks after the accidental introduction of a foreign body. The danger is still greater if the body is septic. One patient seen by Barjon had carried a tracheotomy tube for years without taking any local hygienic care of it. Oxidization had corroded all the circumference of the neck of the inside tube which became detached and entered the right bronchus.

It was a particularly septic body. In spite of every effort, the tube could not be extracted before the tenth day; the patient already had a temperature of 39° C., a broncho-pneumonia had developed and he succumbed in spite of successful bronchial intervention. Foreign bodies in the bronchi therefore must not be left to themselves.

Diagnosis.—When a patient appears with the history of having swallowed a foreign body, a careful examination ought always to be made. The foreign body may be either in the digestive or in the respiratory tract. If it has penetrated into the stomach it becomes a simple matter and elimination will be normal.

On the contrary, if it remains in the thoracic region, it must be considered dangerous. First it must be known whether it is in the œsophagus or in the respiratory tract. In the œsophagus foreign bodies become fixed at certain well defined points. First of all, at a point above the sternal notch; a transverse right or left examination easily shows whether it is in the œsophagus, which is in back, or in the respiratory tract, which is in front. Second, at the area of stricture caused by the aortic arch. This point is located an appreciable distance above the bifurcation of the bronchi, so that the distinction is quite easy to make. Finally, the third point is at the intersection of the diaphragm, foreign bodies of the respiratory tract never descending so low. If the foreign body is not visible radiologically, if there is still some doubt as to its exact location or even if simply to confirm the radioscopic findings, recourse should be had to both bronchoscopic and œsophagoscopic examination.

CHAPTER II

BRONCHIAL AFFECTIONS

IN a general way bronchial affections, of whatever nature, do not give important radiological images. In bronchial processes there is always present an apparent disagreement between the many auscultatory signs and the slight information obtained from radioscopic examination. Processes purely bronchial darken the lung a little. But even a negative examination has its value, for it eliminates as a cause lesions of the pulmonary parenchyma.

Acute bronchitis.—Acute bronchitis does not give any radioscopic image which can be seen on the screen. There is not any defined shadow; at times, a very slight diminution of the general clearness of the lungs. The affection develops very rapidly to produce any change whatever in the bronchial walls; the mucous membrane alone is congested and it does not give any appreciable shadow. There is furthermore no glandular involvement sufficient to modify the hilus shadow.

Chronic bronchitis.—In chronic bronchitis slight modifications of the pulmonary image are quite often seen, but on the whole the general clearness is scarcely changed.

The hilus shadow is a little more pronounced, enlarged and especially elongated towards the base of the lung. The diverging lines which arise from it are often a little more accentuated (peribronchitis), forming broader and darker lines, especially when secretion is abundant. The bases, however, retain an almost normal clearness; the convexity of the diaphragm and the lateral indentation of the costo-diaphragmatic sinus are not modified; the amplitude of the respiratory movements is not reduced.

The appearance of the apex varies; sometimes it is a

little more grayish when a small amount of sclerosis is present, sometimes it is a little more clear if compensatory emphysema predominates.

Bronchial stenosis.—Stenosis of the large bronchus is rather rare and should be described only because Holzknecht has drawn attention to a radioscopic sign which in his opinion would be characteristic of this disease. That is the inspiratory displacement of the mediastinum. The lung on the opposite side fills more quickly and better during inspiration, and pushes back the mediastinum towards the stenosis. There results a lack of equilibrium, so to speak, between the two lungs. The amount of air being less active on the side of the stenosed bronchus, the other lung is distended more quickly and occupies a more considerable space.

The displacement of the mediastinum would be the result of the difference in pressure between the two lungs. Béclère has correctly pointed out that this displacement has nothing pathognomonic and that it may be found outside of any bronchial stenosis. A unilateral pulmonary sclerosis may bring it about, the median space no longer being kept in place under these circumstances by "two equal springs, pulling against each other." In fact the sclerosed lung has become almost immobile while the other one has retained all its elasticity.

Dilatation of the bronchi.—Dilatation of the bronchi is not always recognizable on radioscopic examination. If a patient with this disease is radioscoped without auscultation and without any other information about him, it is highly probable that diagnosis would often pass unnoticed.

In no other thoracic affection is the contrast so marked between the importance of clinical signs and the insignificance of radiological indications.

Often in such cases nothing further is determined than what was pointed out in chronic bronchitis, namely, enlargement and elongation of the hilus shadow which has become more opaque and a more marked appearance of the

RADIOGRAPH 14. COPPER EYELET IN THE RIGHT BRONCHUS

The copper eyelet with a hole in the center is found in the right bronchus, just at the level of the hilus against the right edge of the median shadow.

RADIOGRAPH 15

No. 1389. J. K. Male, 25 years old. Pulmonary tuberculosis. Dilatation of bronchi on right.

RADIOGRAPH 16. DILATATION OF THE BRONCHI

No. 101. P. C. Male. Age 35. Clinical history and examination: Cough; loss of weight; weakness. Hyperresonance over whole chest, harsh prolonged breathing. No râles. X-ray findings: Emphysema. General bronchial dilatation. Some peribronchial thickening.

RADIOGRAPH 17. ADENOPATHY, PRINCIPALLY RIGHT MEDIASTINAL AND HILUS REGION SECONDARILY

There is a diffuse shadow the entire length of the right border of the median shadow, commencing under the clavicle and extending as far as the diaphragm with very appreciable enlargement in the hilus region.

Autopsy (Péhu).—Tuberculous meningitis. A caseous mediastinal adenopathy, predominating on right. Some glands, right hilus. Little or no tuberculous pulmonary change. Double broncho-pneumonia. A discrete miliary tuberculosis of the organs. Tuberculous mesenteric glands.

diverging lines arising from it. Yet in general the clearness of the bases is diminished and in the middle of this diffuse grayish mist it is not uncommon to see either clear bands following along the tract of the dilated bronchi or more opaque shadows situated irregularly and corresponding to the retention of a certain amount of fluid in the dilated peripheral bronchioles. Barjon has never found radioscopic images similar to those of pulmonary cavities. On the contrary, he has always found a very great difference in appearance between a lung affected by even considerable bronchial dilatation and a lung with tuberculosis in process of softening or already filled with cavities. Bronchial dilatation never attains the same degree of opacity as tuberculosis. Opaque shadows are found only when a new process is superadded.

One case of Barjon's proved very instructive in this respect,—a woman with chronic affection of the right lung with cavity signs at the apex, diffuse sclerosis of the lung with resulting secondary dextrocardia. The radiographic image showed obscure foci unequally divided in the two lungs; not many on the left; they were somewhat dense in the middle of the right lung and especially confluent toward the base. The right apex, where cavity signs were heard, remained clear. Dextrocardia was clearly visible.

Examination of the sputum showed absence of Koch bacilli; the tuberculin test was negative even at one-fifth more than the normal quantity. Autopsy showed that the patient had bilateral bronchial dilatation, more marked on the right and predominant toward the apices. There were true sub-pleural cavities in which the dilated large bronchi ended. Besides, there was sclerosis and retraction of the right lung with dextrocardia and symphysis; on the contrary, emphysema was predominant on the left. Death was due to terminal lobular broncho-pneumonia with many scattered foci in both lungs but especially in the lower two-thirds of the right lung. These foci of broncho-pneumonia corresponded to the shadows noted on the radiographic image.

Histological examination confirmed the fact that there was no tuberculosis but ordinary broncho-pneumonia.

In this case, abnormal on account of its location and development, the radioscopic examination was not at fault. It showed that the right apex in spite of the presence of cavity signs had retained its normal clearness and showed opaque shadows only in the region of broncho-pneumonia areas.

The absence of a characteristic radiological image in dilatation of the bronchi is in fact certain proof and allows diagnosis to be made by elimination.

The important clinical signs in dilatation of the bronchi may suggest either tuberculosis in a stage of softening and with cavities at the base, or a center of old encysted pleurisy incompletely evacuated. But in these two cases radioscopic examination ought to show very characteristic images: pronounced opacity of the lung, clear zones corresponding to the cavities, pleural adhesions, disappearance or partial effacement of the costodiaphragmatic sinus, elimination or marked diminution of the respiratory movements in the case of tuberculosis of the base. In the case of an encysted pleurisy there is a defined and circumscribed center with or without an appearance of pyopneumothorax.

In dilatation of the bronchi there is nothing comparable to this; bases simply a little gray, no appreciable pleural reaction, diaphragmatic contour and sinus well preserved, respiratory movements almost normal.

In proportion as the clinical signs resemble one another, the radiological appearance differs. That is enough to affirm diagnosis.

CHAPTER III

TRACHEO-BRONCHIAL ADENOPATHY

THE existence of tracheo-bronchial adenopathy is very common in adults as well as in children. Often it remains latent and does not manifest itself by any functional disturbance. At times it gives rise to disturbing symptoms the origin of which it is very important to know. Investigation of these deep lymphatic manifestations is, therefore, essential in many cases and the ordinary methods of exploration very often do not disclose them. These latent forms scarcely attract the attention of the clinician and yet it is essential to know of their existence in order to make a diagnosis.

Percussion, which seems to be the best method of examination, is a very delicate and uncertain means of diagnosis. When the glands are large enough and so situated as to exert sufficient pressure on the respiratory tract, compressed breathing or coughing may occur, but these manifestations are not common. It is, therefore, indispensable to have a more certain and practical method of investigation.

Radioscopic examination seems to fulfill these demands and diagnosis of tracheo-bronchial adenopathy can actually be affirmed by this method of thorax examination.

Radioscopic Distinction between Different Groups of Glands.—The anatomical description of tracheo-bronchial glands has been made by Guéneau de Mussy and Baréty and since adopted by most anatomists.

It is a radiological distinction with which we are concerned, because according to their location, these different groups of glands give images located quite differently in comparison with the normal radioscopic appearance of the thorax.

There are two main groups:

1. A mediastinal group including all tracheo-bronchial glands, that is, the two pre-tracheo-bronchial groupings right and left and the inter-tracheo-bronchial grouping.

All these glands are situated in the median line between the sternum and the vertebral column in relation to all the important organs of the mediastinum. Their radioscopic images will be mediastinal images.

2. A hilus or pulmonary group made up of many intra-pulmonary peribronchial glands which follow the bronchi subdivided up to the fourth division (Cruveilhier). These glands have a lateral location and give radioscopic images which will be hilus or pulmonary images.

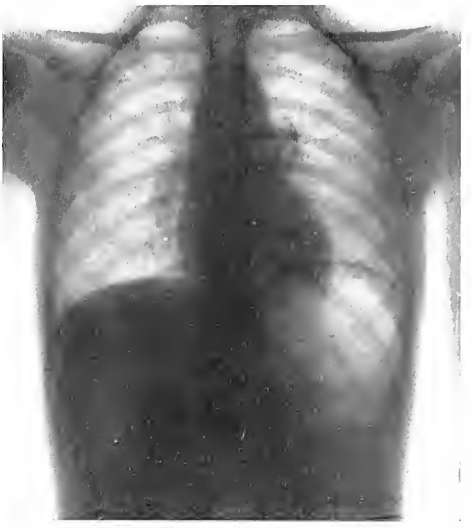
This distinction is radioscopically important, for the images furnished by these different groups should be examined and studied in different positions. It is equally important from a pathogenic point of view, for each of these locations has a different medical significance.

Different Morphological Significance.—Tracheo-bronchial adenopathy of the mediastinal group usually corresponds to the clinical syndroma in children described by Guéneau de Mussy and Baréty. It is found after measles, whooping-cough and other infectious diseases of childhood; it is a gland affection almost exclusively, not in any way affecting the condition of the lung.

According to the degree of pressure, its predominance on the respiratory, vascular or nervous organs, the symptoms that appear are dyspnœa, orthopnea, pseudo-asthmatic, or stridulous crisis, difficulty in breathing, wheezing, cynosis, œdema, vocal paralysis, etc. But even with very important gland masses there is often no appreciable functional trouble.

In adults this same location produces symptoms much less striking and is found in connection with the development of tuberculosis, lymphadenitis, cancer of the breast, œsophagus or stomach.

Adenopathy of the hilus group is much more directly related to the condition of the lung, particularly to the



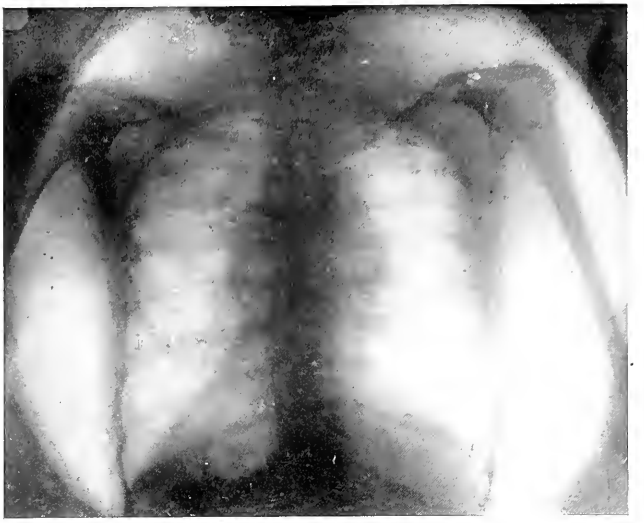
RADIOGRAPH 18. ADENOPATHY PRINCIPALLY IN THE HILUS REGION AFFECTING MEDIASTINUM

No. 1982. L. C. Female. Clinical history and examination: Cough. Slight fever. Palpable cervical glands. Sibilant and sonorous râles both sides, especially left base.

X-ray findings: Hilus region enlarged. Enlarged hilus glands. Bases increased density.

RADIOGRAPH 19. QUESTIONABLE ADENOPATHY OF BOTH THE HILUS AND MEDIASTINUM BILATERALLY

No. 1760. S. F. Male, 15 years old. D'Espine's sign positive. Dullness to 5th dorsal spine. No pulmonary lesion. Tracheo-bronchial adenopathy.



RADIOGRAPH 20. TUMOR OF THE ANTERIOR SUPERIOR MEDIASTINUM AFFECTING THE ADJACENT GLANDS

Enormous shadows in the superior mediastinal region, extending beyond the median shadow on both sides. Extension to the entire hilus of the right lung.

Clinically.—Symptoms of pressure, difficulty in breathing, wheezing, dyspnœa, raucous cough.

RADIOGRAPH 21. A RIGHT, EXTENSIVE PULMONARY INFARCT IN A CARDIAC

Very large heart. Considerable enlargement of the median shadow. The aorta and the pulmonary artery are appreciably deflected to the left. In the right pulmonary field one sees an extended, elongated shadow occupying the lower two-thirds, from the median portion of the shoulder blade as far as the diaphragm. This shadow ends in a point in the lower part.

development of pulmonary tuberculosis as Piéry and Jacques have well shown, but may also precede pulmonary lesions.

These glands alone do not cause any special symptoms, but their occurrence is none the less important on account of the seriousness of the condition revealed. The glands, however, may be found also in the course of less serious affections, as ordinary bronchitis, chronic bronchitis or bronchiectasis which produce an inflammation and permanent infection of the bronchial tract, causing secondarily inflammation and hypertrophy of these intrapulmonary glands.

Radioscopic image and differential diagnosis.—I. The mediastinal glands do not appear at once on radioscopic examination. They must be sought for and that is the reason, perhaps, that they often pass undetected.

In the frontal and dorsal positions the image of the glands is confused with that of the median shadow. This median shadow is very dense, owing to the superposition of successive shadows of the vertebral column, organs of the mediastinum and sternum, which prevents the lighter shadows of the glands from being distinguished. When the glands are many and large their shadow may extend laterally beyond the median shadow, giving it an irregular and scalloped appearance. Sometimes the shadow of the glands projects greatly on one side or the other. But this image may be lacking.

To see more distinctly the shadow of these glands, the median shadow must be separated by having the patient assume different anterior, posterior and oblique positions so that the mediastinum can be investigated. The glands are then seen as a diffuse shadow without definite outline, obscuring the middle portion of the corresponding median clear space and almost level with the bronchial bifurcation. In this connection Schwarz has observed that before radioscopic examination this bifurcation had been placed as much too high. In reality it corresponds to the sixth rib

posteriorly; consequently, mediastinal adenopathy ought to be looked for at this level or above, while pulmonary adenopathy, situated lower down, corresponds to the seventh or eighth rib.

Mediastinal adenopathy, especially if large and if its image projects beyond the median shadow, may, strictly

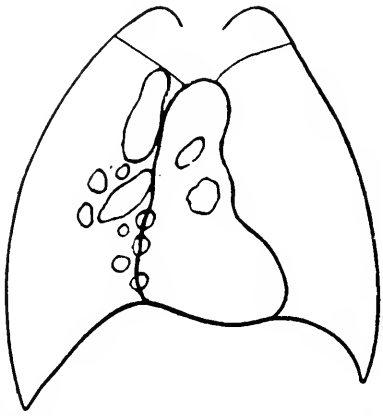


FIG. 19. DIAGRAM OF THE DISTRIBUTION OF THE GLANDS, AFTER AUTOPSY

Predominance of mediastinal glands on the right side occupying the entire length, superimposed one upon another from the diaphragm up to the clavicle. Two caseous glands in the right hilus (see Radiograph 17).

speaking, be confused in children with hypertrophy of the thymus and in adults with tumor of the mediastinum.

Differential diagnosis from thymic hypertrophy is comparatively easy, the latter giving a radioscopic image more elevated, located under the clavicles and usually with a contour almost rectilinear and symmetrical on both sides. This image superimposed on that of the heart has roughly the appearance of an hour-glass. Besides, thymic hypertrophy is found only in the new born while tracheo-bronchial adenopathic syndroma is rather the usual accompaniment of childhood. Age will therefore be an important factor to consider and, on the other hand, as the thymus and other

glands are each amenable to radiotherapic treatment, in case of doubt, irradiations can always be prescribed. In adults the diagnosis of mediastinal tumor is often difficult, the tumor being accompanied by mediastinal adenopathy. However, the tumor usually reaches a size which the glands do not and is accompanied by phenomena of pressure uncommon in simple adenopathies.

II. The hilus glands, due to their intrapulmonary lateral

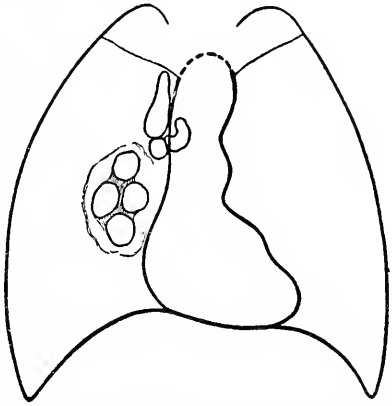


FIG. 20. DIAGRAM OF ARRANGEMENT OF GLANDS AFTER AUTOPSY
Adenopathy, especially of the hilus region, four caseous glands adherent, situated on the right. On the mediastinal side a rather large gland with long vertical axis and two other smaller glands (see Radiograph 18).

location, give an image distinct from the median shadow easy to see in the frontal and dorsal positions.

This shadow is confused with that of the hilus which, consequently, is broader, longer and more dense. The extension is on the side of the lung principally toward the base.

When it is not too extensive, a clear thin space separates it from the median shadow, but if the adenopathy progresses even a little, the hilus shadow is extended and fuses with the median shadow from which it cannot be distinguished. This appearance coincides ordinarily with rather extensive and advanced pulmonary lesions. But early tuberculosis

of the glands of the hilus with caseation and without pulmonary lesion is not uncommon.

The hilus shadow is not always homogeneous; often darker spots appear in the middle of the diffuse grayish tint, due to the presence of denser glands, particularly fibrous or calcareous glands. It is more apparent on the right where nothing obscures it, while on the left it is largely covered by the heart shadow.

Piéry and Jacques attach a certain amount of importance to the appearance of the hilus shadow in the different forms of tuberculosis. It should appear as a uniform band, not well defined, in incipient tuberculosis; a very marked homogeneous band in the subacute forms; dark spots should stand out on this grayish band in chronic forms; and finally in latent tuberculosis very clear spots with well defined outlines should be seen. In reality, it is difficult to be guided by this examination. Tuberculosis which remains a long time latent may, according to circumstances, develop into an acute, subacute or chronic form. All that is necessary to bear in mind is that the presence of deeper and more defined shadows in the midst of homogeneous hilus bands corresponds to sclerous or calcareous glands, denser than simple hypertrophied or caseous glands.

In fact Piéry, Jacques and Nogier have demonstrated that by examining under an equal thickness of layers simple hypertrophied, sclerous, calcified or caseous glands, shadows of different values will be obtained.

Calcified and sclerous glands give black spots with well defined outline. Simple hypertrophied glands give a deep shadow with ill defined outline. Purely caseous glands seem to be the most transparent.

Diagnosis of these gland images of the hilus is not always evident. Pleural or pulmonary lesions may furnish analogous images.

A thickening of the pleura in the region of the hilus may give diffuse shadows but they are generally less apparent, more homogeneous and especially less mobile. When the

tube is moved the gland shadows are displaced in the opposite direction and sometimes from one intercostal space to another on account of their relative distance from the screen and their somewhat deep location. Thickenings of the pleura which are more superficial and are brought nearer the screen are displaced very little or not at all.

Small pleural encysted collections in the region of the hilus give an image much more like that of the glands. This has already been spoken of in connection with encysted pleurisy. Diagnosis should be made particularly according to development; encysted pleurisy either extends well towards another portion of the pleura (interlobe, large cavity), and then gives a characteristic image; or resolves and disappears in a few days when the glands give an image, if not permanent, at least persisting for a long time.

Tumors of the mediastinum give more important shadows and are most often accompanied by secondary adenopathy.

The presence of a diffuse, extensive shadow going well beyond the limits of the properly called hilus region will probably mean a concomitant lesion of the lung, and auscultation will show the condition of the lung. It must not be forgotten, however, that glands of the hilus are prolonged as far as the bronchi of the fourth division and that they may give rather extensive images.

In summing up, two distinct forms of tracheo-bronchial adenopathy exist: a mediastinal and a hilus form, which ought to be distinguished radiologically. Clinically these forms are most often associated.

Barjon has insisted on this division in order to draw attention to the different location of these two groups, the particular appearance of their images and the different way in which they must be studied: frontal and dorsal positions for the glands of the hilus; oblique positions for the mediastinal glands.

In reality, this distinction is somewhat artificial, for the same causes ordinarily affect both groups. Mediastinal adenopathy in children is usually accompanied by a hilus

adenopathy; hilus adenopathy in adults almost always ends with a mediastinal adenopathy.

Too much importance, therefore, must be not attached to this distinction which is only meant to bring out better the anatomical and radioscopic individuality of each group. What ought to be borne in mind is the clinical and prognostic value of adenopathy which is always serious. Undoubtedly in adults it may sometimes indicate only a chronic and benign affection of the bronchi, but very often in children with general poor health they are an almost certain indication of tuberculosis.

PART IV

RADIOLOGICAL STUDY OF THE LUNGS

CHAPTER I

VASCULAR PROCESSES

THE vascular processes: congestions, œdemas, infarct give, from a radiological point of view, a series of abnormal shadows which it is well to recognize but which do not have a pathognomonic value. It is always the clinical examination which reveals these manifestations. The radioscope can only serve to give information which confirms their existence and allows one to determine their location.

CONGESTIONS.—Pulmonary congestions are frequent and of very different forms. They always show a very perceptible diminution of clearness in the zone attacked when the thorax is examined on the screen. We can distinguish: primary active congestion, secondary active congestion, passive congestion.

(a) *Primary active congestion.*—Here it is an acute disease which resembles pneumonia and pleurisy and of which the diagnosis is sometimes rather difficult to establish. There are three clinical forms to be distinguished: The pneumonic form (Woillez), the pleuro-pneumonic form (Potain), and the spleno-pneumonic form (Grancher). Radioscopic examination may be useful in differentiating these acute congestions from true pneumonia and also in distinguishing the various forms of congestion which have just been pointed out. Diagnosis in frank pneumonia is often difficult, clinically. Radioscopic examination shows that a shadow as opaque or as clearly defined as in pneumonia never exists. The pneumonic triangle is lacking. When the signs of effusion are added to pulmonary symptoms, radioscopic examination will indicate whether or not there is fluid in the pleura. If the existence of a slight concomitant effusion is established, it indicates pleuro-pneumonic congestion of the Potain type.

If the radioscope shows the absence of all effusion, then we have to do with the spleno-pneumonic form of Grancher.

(b) *Secondary active congestion.*—Attacks of active secondary congestion are produced in the course of different affections—infectious diseases, especially typhoid fever, grippe, malaria, etc. Radioscopic examination in these cases shows only diffuse shadows, at times lighter and without any particular characteristic. Its rôle is then supplementary.

(c) *Passive congestion.*—This occurs at the bases, either in patients with prolonged dorsal decubitus or more often still in cardiacs. Such congestion is often accompanied by a small amount of œdema and when it recurs, it sets up in the lung a sort of chronic inflammation which ends in sclerosis. The diffuse radioscopic shadow which is then seen at the base of the lung is often the result of this triple process,—congestion, œdema, sclerosis.

Œdemas.—Œdemas give diffuse shadows which resemble to a noticeable degree those produced by congestions. Acute active œdema which is produced in the course of arterio-cardiopathies and nephritis is shown by a diffuse shadow of variable extent, occupying sometimes two-thirds of both lungs, more marked at the bases, less dense toward the apices. It may be much more marked on one side, at times clearly unilateral.

Passive chronic œdema attacks the bases and is found in mitral cardiacs; it is shown on the screen by a thinning, more or less marked, of the thoracic clearness toward the lower portion of the lung.

Radioscopic characteristics common to œdema and to congestion of the bases.—These passive conditions are seen always on the screen as diffuse shadows, ordinarily not very deep and of very variable extent. They are distinguished by certain characteristics from shadows produced by effusion, even though this is slight. The opacity is never as intense as that produced by effusion. The permeability of the lung having been retained in part, the air which penetrates into the alveolars modifies the shadow produced by excess of

serous fluid. In inspiration the base becomes sufficiently cleared for one to distinguish plainly the convex contour of the diaphragm and the notching of the costodiaphragmatic sinus. The movements of respiration have kept their regularity and their extent. It is then certain that there is no question of effusion.

Infarct.—Infarct of the lung, when it affects a sufficient area, can by radioscopic examination present a very perceptible abnormal shadow. Contrary to what the anatomic aspect of the lesions would lead one to suspect, this shadow is not very opaque and does not usually show contours clearly defined. It does not have the frank triangular form and should not be confused, for example, with the pneumonic triangle. It has neither its appearance, its intensity, nor its position. It shows ordinarily on the screen as a blurred spot with shaded contours, situated most often in the full pulmonary field, but rather in the lower part of this field. This blurred aspect of infarct is due, undoubtedly, to the inflammatory zone which surrounds it, already well described by Laënnec, and which contains a certain degree of œdematous infiltration. On the radiographs the contour of the infarct is a little more clearly visible but the shadow remains not very opaque unless it is a very extensive infarct. Even in that case one never sees an intensity comparable to that of lobar pneumonia.

CHAPTER II

ACUTE INFECTIOUS PULMONARY PROCESSES

PNEUMONIA.—Radioscopic examination is valuable in pneumonia either to facilitate diagnosis, to determine its location, or to follow its development. By reason of its form and its different development it is invaluable in distinguishing the characteristics of pneumonia in children from that in adults.

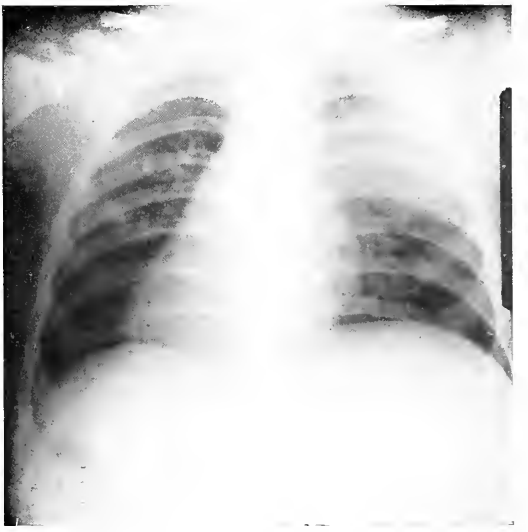
Pneumonia in children.—Radioscopic study of infantile pneumonia has been made in a very complete manner by Weill and Mouriquand in numerous reports from which we shall quote largely. The pneumonia of childhood, and in particular that of infancy, is most often difficult to detect because the physical signs may appear only slowly, or even may be lacking completely. The pneumonia with its general symptoms—fever, vomiting—precedes pulmonary localization, which often becomes perceptible only on the 4th, 5th and even the 9th day. Radioscopic examination, on the contrary, early discloses pulmonary localization, showing an image quite characteristic.

The pneumonic triangle.—This image appears under the form of a triangular, opaque shadow—"primary triangle"—the base of which corresponds to the axilla while the apex is directed towards the hilus. In the beginning this figure is clear; later it may be modified by processes drawn out toward the apex or toward the base, diffusing, extending, or even deforming the shadow. Then, during the period of resolution, these superadded shadows disappear first and the primary figure is restored again under the name of "triangle de retour."

Diagnosis.—Radioscopic examination is a valuable aid in diagnosis, for it reveals the existence of a pneumonic focus

RADIOGRAPH 22. RIGHT FRANK PNEUMONIA WITH RAPID DEFERVESCENCE IN A CHILD

The upper external portion of the right pulmonary field is occupied by a triangular shadow, very opaque, with contours clearly marked (pneumonic triangle).



RADIOGRAPH 23. ACUTE RIGHT LOBAR PNEUMONIA IN A CHILD WITH RAPID FEBRILE DECLINE

No. 1952. R. O. Male, 15 months old. Pneumonia in right upper lobe of 4 days' duration with typical clinical history and physical findings.

before auscultation. Often auscultation reveals nothing, or scarcely a diminution of the vesicular murmur, the breathing and râles appearing only afterwards. There are even pneumonic foci which remain latent to the end and which would never have been brought to light without the radioscopic screen. On the other hand, these proofs do away with the idea of a central pneumonia which would explain the late appearance of physical signs. Indeed, the shadow of the pneumonic triangle begins always at its base, and this base is always cortical since it develops in the axilla.

Finally, the radioscope never shows in any case a primary central focus without some relation to the cortical portion of the lung. In short, central pneumonia does not exist, but everything progresses clinically as if it did.

Prognosis.—Radioscopic examination furnishes also an element of prognosis in the study of infantile pneumonia. In fact, when the pneumonic focus remains limited to the primary triangle without any tendency to extend, when the localization appears slowly, the prognosis is favorable. An early localization with rapid extension indicates a more serious form. Finally, when the localization appears at the outset at the same time as fever and general symptoms, the pneumonic triangle has only a transitory existence and hepatization rapidly affects the whole parenchyma. This evolution occurs with a particularly serious form and in this case infantile pneumonia resembles in form and development that of the adult.

Pneumonia in adults.—Radioscopic examination is of less interest with adults than with children in the course of pneumonia. Clinical diagnosis is, in general, much easier with the adult where physical signs are rarely lacking and are even somewhat early. On the other hand, adult pneumonia is a disease much more serious than infantile and the carrying of such a patient to the radioscopic room in acute, developed pneumonia is at the same time a great difficulty and a grave danger.

Therefore, the examinations are exceptional in the early

stages and are usually made during the first days which follow defervescence. This is perhaps one reason which explains the rarity of the pneumonic triangle in the adult. The late examination does not give the primary triangle phase, but most often only a diffuse lobar shadow. Yet we must confess that if the primary triangle is rare in adults, the "triangle de retour" is none the less so, which leads us to suppose that the triangular form is not as a rule in the adult the pathognomonic image of pneumonia. It does occur, however. This has been pointed out by Bret and by Mollard in the course of prolonged pneumonia. Paillard has seen two cases of it. Barjon observed it, as shown by the accompanying radiograph (Radiograph 24), but it is not the usual form. The early lobar form and the slowness of resolution distinguish radiographically pneumonia in adults. In children the pneumonic triangle is the rule. It often constitutes in itself the entire pneumonia. The lobar form is late and more rare. In adults the pneumonic triangle is less frequent and appears to be only a passing form and the entire lobe is rapidly affected.

The most characteristic picture is that of pneumonia of the apex. The whole upper lobe is obscured, as far down as the interlobar line which separates it from the clearness of the lower lobe. The line of demarcation is clear, the contrast striking.

In pneumonia of the base the picture is less characteristic, the shadow more diffuse, its outline less certain.

In massive pneumonia the diffuse shadow covers the entire hemithorax and the lung with complete hepatization shows a marked increase in size so that there results a certain amount of displacement of the heart and of the mediastinum to the opposite side, as occurs in pleurisy. It is not rare besides to see these pneumonias complicated with a slight pleural effusion.

The resolution of pneumonia can be easily followed on the radioscopic screen. In children, when pneumonia is benign (which is the rule), and when the radioscopic picture is

limited to the primary triangle, resolution is rapid and in a few days all trace of an abnormal shadow has disappeared in the lung. It is only in the more serious forms when the lobar shadow succeeds the primary triangle that resolution becomes slower and the abnormal shadow still persists at the end of several weeks.

In adults the resolution of pneumonia is always slow, but in certain serious and extensive forms it is prolonged in a manner quite remarkable. The abnormal shadow of the lung, more transparent and modified, persists a long time after the disappearance of all physical signs. Barjon found it in a case two and a half to three months after the beginning of pneumonia, but usually it can be followed for at least six weeks. The shadow becomes lighter, less homogeneous, loses form and sometimes is reduced to a long band, more or less irregular, almost always cortical, but it is effaced only very slowly and a long time after the disappearance of all auscultatory signs. It may be said, then, of the pneumonic shadow that whereas in children it often precedes by several days the appearance of stethoscopic signs, it outlasts them in the adult sometimes for several weeks.

Has the pneumonic triangle a specific value in the radiological diagnosis of acute frank pneumonia?—When it exists, its positive value is unquestionable, especially with children. No other thoracic disease gives a triangular shadow with an axillary base and with contours so distinct. Interlobar pleurisy gives a more regular band which has not the form of an angle. It begins in the region of the hilus and extends afterwards to the whole interlobe. The pneumonic triangle, on the contrary, begins at the axilla and the base of the triangle is visible often before its apex. Consequently its progress is inverse.

It would seem a priori that infarct by reason of its anatomical form would show on the screen a clear picture in triangular form, but it does not. Infarct, contrary to what one would think, shows on radioscopic examination light

borders poorly defined by reason of the inflammatory process which surrounds the hemorrhagic focus. However, infarct is exceptional in children. In certain conditions other pulmonary processes and in particular tuberculosis may show the axillary triangle.

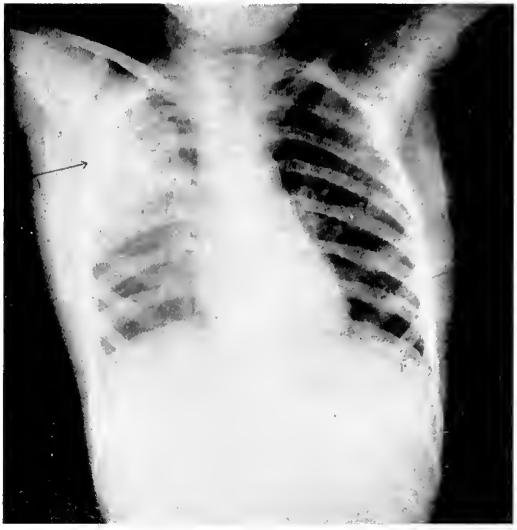
The development of tuberculosis is often brought about only through a series of pneumonic processes. At different times Barjon established the presence of the axillary triangle in tuberculous patients. Others have made the same statement. Nevertheless, this pneumonic picture, however clear it may be, is distinguishable from that of frank pneumonia, for there are seen either on the same side or on the opposite side, shadows caused by pre-existing tuberculous lesions (see Radiograph 26).

Clinically these pneumonic foci show neither the same development nor the same symptoms as frank pneumonia. These facts do not at all lessen the value of the pneumonic triangle. When the triangle is wanting, one has no right to deny pneumonia. We have seen that this characteristic picture is rare, transitory, in adults; that it may be wanting in a very great number of cases. In children even the triangle may not be present, as Weill and Mouriquand have shown, but that is much more rare.

To sum up, the triangle, when it exists, has all the value of a positive sign and one must conclude the existence of a pneumonic process.

Broncho-Pneumonia.—Broncho-pneumonia appears under two different forms: a diffuse, extensive, or pseudo-lobar form; and a form with distinct, disseminated foci, or lobular. In these two cases the radioscopic pictures are quite different.

Pseudo-lobar form. — Pseudo-lobar broncho-pneumonia never shows an outline as definite as pneumonia. It is exceptional to see it occurring within the exact limits of one lobe. Most often it affects only a more or less important fraction of the lobe, or spreads from one lobe to another, limiting itself either to the anterior portion, or more often,



RADIOGRAPH 24. ACUTE LOBAR PNEUMONIA OF THE RIGHT APEX IN AN ADULT. PNEUMONIC TRIANGLE

No. 111. M. T. Female, 7 years old. Pneumonia in right upper lobe of 5 days' duration with typical physical findings.

RADIOGRAPH 25. TOTAL DIFFUSE PNEUMONIA OF THE RIGHT LUNG IN AN ADULT WITH PREDOMINANCE TOWARD THE BASE. DISPLACEMENT OF THE HEART AND MEDIASTINUM

Diffuse and total obscurity of the entire right lung, more marked in the lower two-thirds. The preservation of the convex contour of the diaphragm and of the deep indentation of the costodiaphragmatic sinus shows that there is no effusion in the pleura. Nevertheless one sees some displacement to the left of the heart and of the mediastinum on account of the extent of the pneumonic process and the increase in volume of the right lung which results from it.

to the posterior portion of the lung. Evidently such a localization cannot give shadows as distinct and with contours as definite as those of pneumonia. Broncho-pneumonia never gives the picture of the pneumonic triangle; but shows only diffuse shadows, obscure, poorly defined, and often scarcely apparent. The clinical and radiological symptoms taken together permit of a diagnosis.

While in penumonia clinical signs may be lacking or remain unsuspected in the beginning, there is already a very distinct opaque shadow in the axillary region or in the upper lobe. In broncho-pneumonia, on the contrary, the signs are very audible and extensive (breathing, moist râles) and it is surprising on radioscopic examination to see shadows so light, diffuse and difficult to make out in spite of a train of symptoms so alarming. This is due to the dissemination of the lesions and the persistence of normal areas either in front or in back on the surface of the lung. The relative clearness retained in the normal areas lessens the value of the shadows thrown by the diseased areas while in penumonia, which forms a solid mass, the opacity is more apparent. It seems, too, that the anatomical process, which is different in pneumonia and broncho-pneumonia, helps to accentuate this contrast in shadows. There are, however, cases where the differentiation is more difficult, where the focus of broncho-pneumonia, more condensed, gives a shadow more important and somewhat difficult to distinguish from that of pneumonia, especially when it occurs in the upper lobe. Barjon demonstrated several cases of it—one in Dr. Pehu's service which was confirmed by autopsy.

Lobular form.—Lobular broncho-pneumonia appears anatomically under the form of disseminated, distinct foci. These foci may be very near together and confluent in certain parts of the lung, obscure and far apart in others. Nevertheless, as the mass of the lung has retained its transparency, each of these foci gives, on radioscopic examination, a definite shadow which stands out against the clear background of the parenchyma. The radioscopic image of

this form of broncho-pneumonia is thus made up of a series of distinct shadows, more or less confluent, and separated from one another by clear spaces. It has exactly the appearance of certain forms of chronic tuberculosis with disseminated foci which, however, are nothing else than foci of tuberculous broncho-pneumonia. The lung shows a mottled appearance.

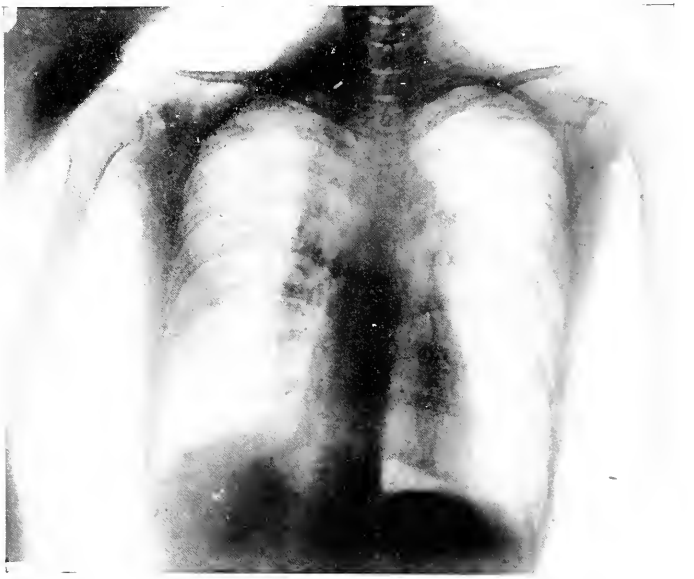
This appearance is clearly shown in Radiograph 16—a series of diffuse, definite shadows, much more confluent at the right towards the base and the region of the hilus, much more questionable at the left. This was a case of a lobular broncho-pneumonia, verified by autopsy, in which the confluence of the diseased centers was perfectly visible on the plate. It was a common broncho-pneumonia, following a chronic bronchial infection, and not a case of tuberculosis. The clinical development, the absence of bacilli in the sputum, and the absence of tuberculin reaction indicated that tuberculosis was not a cause. Autopsy and histological examination of the lung confirmed this. It is evident then that simple lobular broncho-pneumonia may give a radioscopic picture analogous to that of certain forms of chronic tuberculosis with disseminated foci and that it is the clinical side alone which informs us of the nature of the pulmonary process.

Abscess of the Lung.—The metastatic or pyemic abscess following infectious diseases, or surgical pyemas will not be dealt with: nor migratory or secondary abscess following abscess of the liver, colon, or mediastinum. Pneumonic abscess only will be discussed.

Abscess of the lung is rare, but to determine it radioscopic examination is of unquestionable service. Clinically, this diagnosis is almost impossible except in exceptional circumstances. Patients who are affected show sometimes very marked intermittent fever, varied thoracic symptoms most often without anything definite, and a somewhat serious general condition. An abscess usually follows pneumonia, broncho-pneumonia, or bronchial infection; the

RADIOGRAPH 26. PSEUDO-PNEUMONIC TRIANGLE IN A TUBERCULOUS PATIENT

The upper external portion of the right lung shows an opaque triangular shadow like the pneumonic triangle but the apex of the lung on the same side shows clear and dark areas side by side which suggest cavities, while the shadows already extensive on the left side indicate somewhat advanced bilateral tuberculous lesions.



RADIOGRAPH 27. PULMONARY EMPHYSEMA

Elongation of the thorax with increase of clearness of the pulmonary fields, enlargement and elongation of the hilus shadow made more apparent by the clearness of the lungs. Definite and deeper areas in the shadow of the hilus corresponding to fibrous or calcareous glands. Diverging lines of sclerosis, starting at the hilus and spreading out like a fan into the two lungs; enlargement of the intercostal spaces; elongation of the heart shadow by tension on the mediastinum.

thoracic symptoms are ascribed to the primary lesion and do not attract any special attention. It is only the appearance of a vomica followed by cavity signs which makes one think either of an abscess or of an encysted pleurisy. But the vomica may be absent, and in any case it is preferable to make the diagnosis before.

Barjon has observed two cases of lung abscess and thanks to the radioscopic examination he could determine the loca-

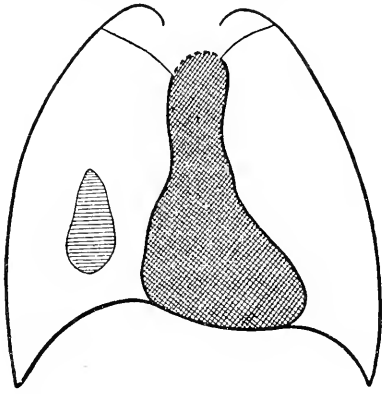


FIG. 21. ABSCESS OF LUNG
Limited shadow in the postero-inferior portion of the right lung

tion and intervene before any vomica or complications. The first of these patients passed as tuberculous, had grown thin, showed marked intermittent fever, coughed, expectorated, and at first sight gave the impression of phthisis. As he lived in the country, no laboratory examination could be made—neither examination of sputum nor tuberculin test. Radioscopic examination of this patient made at home by means of a portable apparatus showed an almost normal clearness of the pulmonary areas with no obscurity of the apices.

In the middle part of the right pulmonary area but a little nearer the base was an abnormal shadow, oval in form, the size of a hen's egg, and very apparent although its contours were a little diffuse. This shadow had no relation either to

the hilus, the median shadow, or the wall. It seemed independent of the pleura and appeared in the middle pulmonary parenchyma. The oblique and transverse examinations showed that the relation was closer to the posterior than to the anterior wall. Barjon was able to advise a posterior approach to the affected area and to determine the intercostal space where the incision ought to be made. Surgical intervention demonstrated the value of these deductions and brought to light a somewhat deep pulmonary abscess, which was emptied and drained. The patient recovered.

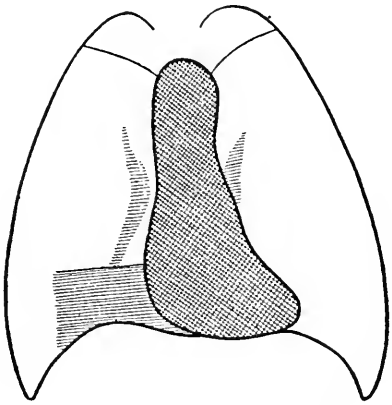


FIG. 22. ABSCESS OF LUNG
Rather extensive opaque shadow situated in the inferior portion of the right pulmonary field on the internal border and in the anterior portion

The second case was a man forty-six years old who, following herpetic sore-throat and a series of mouth herpes, had shown somewhat serious thoracic conditions. Stethoscopic examination made at intervals was negative. The temperature had varied for three months between 38° and 39.5° C. Radioscopic examination showed a very opaque and somewhat extensive abnormal shadow, in the anterior, lower and internal parts of the pulmonary field.

This shadow continued almost without a line of demarcation the median shadow and descended as far as the diaphragm. In this case it was impossible to tell whether the

affected area was interpulmonary or whether it was an encysted pleurisy. Surgical intervention being indicated as in the other case, it was practised some days afterward and showed that it was a lung abscess and not encysted pleurisy. In this case also the result was excellent.

These two cases are sufficient to show the important part played by radioscopic examination in abscess of the lung, as also in all pleuro-pneumonia localizations in which surgical intervention is indicated.

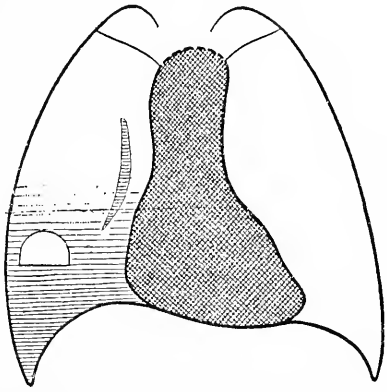


FIG. 23. CENTER OF PLEURO-PULMONARY GANGRENE OF THE RIGHT BASE WITH HYDROPNEUMOTHORAX

PULMONARY GANGRENE.—Pulmonary gangrene comes clearly into the category of thoracic affections where radiological examination ought never to be neglected. Undoubtedly clinical diagnosis is easier on account of the characteristic odor of the breath, which attracts attention, but it is useful to be able to determine the location and extent of the lesions so as to indicate treatment. The radioscopic pictures vary according to the clinical form which the gangrenous process assumes. The principal forms are: bronchial, pleural, pneumonic. It is the last two which offer most interest because surgical intervention is seldom indicated in the bronchial form, while it may become urgent in the other two. The part of the radiologist is to furnish

to the surgeon all useful information, either as to when to intervene, or as to how to approach the gangrenous center.

Béclère and Guisez have determined by radioscopic examination and the radiograph the site of a gangrenous center located in the lower two-thirds of the right pulmonary field. It was shown by the characteristic image of a hydropneumothorax. Examination under different conditions showed that the central cavity was equally distant from the anterior and posterior surfaces, consequently difficult to approach. This information made treatment by large injections of antiseptic oil preferable to uncertain surgical intervention. This treatment was completely successful. In three cases shown by Frankel, operation on the contrary was decided upon, which also was followed by good results.

More recently, Henri Béclère was able to localize a gangrenous center in the region of the hilus and to indicate a dorsal course. This allowed Lejars to come at once upon the cavity, which was emptied and drained.

Quite lately, in a patient of Dr. Gallavardin's a center of pulmonary gangrene was localized at the right base and seen on the screen as a very clear hydropneumothorax.

CHAPTER III

CHRONIC PULMONARY PROCESSES

PULMONARY EMPHYSEMA.—Pulmonary emphysema may be localized in a portion of the pulmonary parenchyma. It is most often either at the apex or on the anterior surface of the lung and in this case it scarcely ever gives a radioscopic picture. It is secondary to other lesions—in particular, to tuberculosis, which often goes unnoticed on account of the increase in clearness due to the distended emphysematous alveoli.

Generalized emphysema is quite different and is ordinarily seen on the radioscopic screen by a succession of important characteristic changes: exaggerated clearness of the pulmonary fields, disappearance of the shadow on the sides, deformation and enlargement of the thorax, appearance of abnormal shadows.

Exaggerated clearness of the pulmonary fields is total and permanent. While in a normal subject the difference in clearness is considerable between inspiration and expiration, in the emphysematous it is immaterial. In the normal lung, in inspiration the clearness increases in intensity, especially toward the bases, and in forced inspiration these are lighted up in a quite remarkable manner. In expiration, on the contrary, in proportion as the air is driven from the alveoli, the pulmonary fields become obscure and take on a diffuse, grayish tint. In forced expiration there is difficulty in distinguishing the convexity of the diaphragm from the outline of the heart.

In the emphysematous, where the lung is distended with air and the alveoli have lost all elasticity and become unable to expel the air they contain, there is no longer any differ-

ence in clearness between inspiration and expiration because in both the lung remains inflated with air.

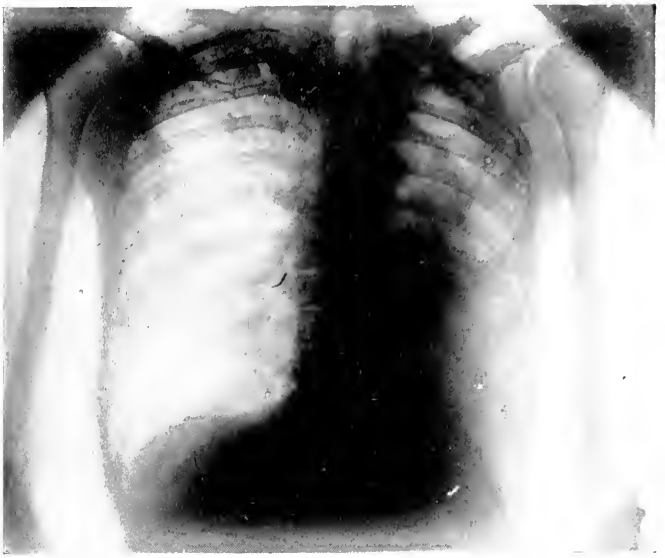
Deformation of the thorax in the emphysematous is characterized radiologically by an important elongation. The thoracic cavity appears increased vertically; the ribs are more elevated, more horizontal and in consequence of this change of direction, the intercostal spaces are enlarged.

There results at the same time a lowering of the diaphragm and the arch becomes flattened. The convexity of the dome is diminished, the depth of the costodiaphragmatic sinuses is reduced, as well as the extent of the respiratory movements. The lowering of the diaphragm causes a tension on all the organs of the mediastinum and on the heart which appears more vertical.

Abnormal shadows appear, ordinarily small in area but made more visible by the increased clearness of the pulmonary fields. These shadows are in relation to the primary or superadded lesions, for it is admitted more and more that emphysema is only the result of older inflammatory processes.

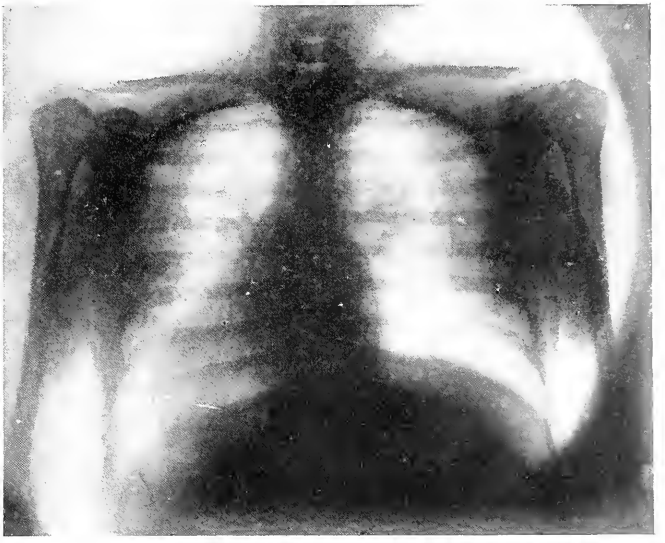
Patients often show cicatrices of old healed lesions, affecting by preference the apices, sometimes as small defined shadows corresponding to old tuberculous cicatrices, sometimes by diffuse obscureness due to a certain amount of apical sclerosis. Often there is at the same time an enlargement and an elongation of the hilus shadow. This anomaly is caused by the existence of small inflammatory or sclerotic nodes associated with the diffuse sclerosis of the peribronchial tissue radiations. There are clearly seen upon the screen and on the radiographic plate dark, diverging radiations arising in the shadow of the hilus and gradually shading into the clear lung. There is often seen also diminution in the shadow of the ribs which become less visible; their contours are more shaded and as if surrounded by a sort of halo because of the increase in thoracic clearness.

Pulmonary Sclerosis.—In contrast to emphysema, sclerosis is anatomically a thickening of the pulmonary parenchyma and contraction of the lung, and consequently,



RADIOGRAPH 28. TUBERCULOSIS OF THE LEFT LUNG REMAINING UNILATERAL FOR EIGHT YEARS. LARGE CAVITIES OF THE APEX. SCLEROSIS WITH CONSEQUENT PULMONARY RETRACTION. INSPIRATORY DISPLACEMENT OF THE MEDIASTINUM TO THE LEFT. MORE RECENT LESIONS IN THE RIGHT APEX

Total obscurity of the left hemithorax with large clearer zones in the upper half (cavities).



RADIOGRAPH 29. INCIPIENT TUBERCULOSIS

Clinical signs more important than radioscopic signs. Woman of eight months pregnancy. Deformity of the thorax, ribs and clavicles. Clearness of the apices quite well retained. Obscure, diverging lines from the hilus region on both sides and spreading out like a fan into the pulmonary fields. Clinical examination—at the right apex diminution of sonorousness. Increase of fremitus, sensitiveness on percussion; great diminution of vesicular sound. Diffuse bronchitis over the entire right lung; no loose râles. At the right apex the clinical signs are more important than the radioscopic.

from a radiological point of view, is seen as a decrease in clearness and reduction of the pulmonary field. When local, sclerosis is seen on the screen as a diffuse, well defined obscurity; when generalized, it is characterized by total diminution in the clearness of the pulmonary fields and the invariability of the diameters of the thorax in inspiration and expiration.

In the case of unilateral sclerosis, Béclère has drawn attention to an important radioscopic sign consisting of the displacement of the mediastinum on the diseased side during deep inspiration. The unaffected lung which has retained its elasticity takes in a greater amount of air, gives a greater pressure and more considerable volume. Therefore it presses considerably upon the mediastinum and displaces it to its own advantage. Unilateral sclerosis may be localized in one lobe: either in the upper lobe, which is most frequent when it succeeds an acute lobar pneumonia, or in the lower lobe, when it is the result of a series of congestive and œdematous attacks like that seen in certain cardiac cases.

Circumscribed scleroses are: cicatricial sclerosis, seen as limited shadows which serve to establish retrospective diagnosis of the primary lesions which have caused them; abscess of the lung; areas of pulmonary gangrene; old tuberculous lesions; hydatid cyst; infarct, etc.

Pneumoconioses, and particularly anthracosis, which is the most important form, should be classed with pulmonary sclerosis, but no special radiological study apparently has been made on the subject.

Atelectasis.—Atelectasis is a particular condition of the lung arising from the disappearance of air in the alveoli. There results radiologically a more considerable opacity of the atelectasized area in comparison with the parts which have retained their entire permeability.

Atelectasis may be total or partial. Total atelectasis occurs under two forms: in the new-born, where breathing has not occurred, it is bi-lateral; in the patient with a well established artificial pneumothorax, it is unilateral.

In the new-born the radiological appearance of the lungs changes totally according to whether one has to do with lungs which have never functioned or with those, on the contrary, that have undergone alveolar distention following penetration of air. It has been suggested to use in legal medicine radiographs of the new-born to determine whether the child has or has not breathed. According to Vaillant, the radiographic appearance of the lungs, stomach and intestines is entirely characteristic in the child which has lived. None of these organs is visible in a child that has not breathed at all. According to Bouchacourt, if air is forced into the child through the mouth instead of its having breathed spontaneously, gas is found in the stomach and lungs but there is never dilatation of the pulmonary apices. These radiological findings have been disputed by Béclère, Ménard, and later by Bordas, so that, from a purely legal point of view, only a relative value can be attached to these findings.

Complete unilateral atelectasis occurs through the operation of Forlanini, or artificial pneumothorax. When intervention is entirely successful, and nothing interferes with complete collapse of the lung, this organ retracts, the air is expelled. Atelectasis then occurs and the lung becomes much more opaque to Roentgen rays. It becomes much more clearly visible on the radioscopic screen. Its contours are raised on the gaseous clearness of the inflated thoracic cavity and make it appear like a narrow band superimposed on the median shadow.

Partial atelectasis is most often the result of compression. It usually follows pleuritic effusion and is localized in the lower parts of the lung. Radiologically, it appears as a diffuse obscurity in addition to that produced by exudates and thickening of the pleura. It is also seen in the left base in patients with marked hypertrophy of the heart following cardiopathy, nephritis, pericardial adhesions. These light shadows, diffuse and poorly outlined, show absolutely nothing characteristic from a radiological point of view, but are a help in confirming the clinical diagnosis.

CHAPTER IV

PULMONARY TUBERCULOSIS

THE radiological study of pulmonary tuberculosis is of great interest. This disease represents almost the whole of pathology in its innumerable forms, variations of onset, development and in its many complications.

Radiological examination will be of value if it can help detect latent forms of tuberculosis which show no clinical or stethoscopic signs. The recognition of these cases makes easy the interpretation of certain diagnostic signs otherwise difficult for even the best informed physician. Its part will be more important still if we can, in certain cases, find the lesions at their very beginning and pronounce an earlier diagnosis which will make treatment infinitely more efficacious and increase greatly the chances of cure. Finally, its value will not be insignificant if it confirms the clinical diagnosis and allows us, on the other hand, to separate from this confused mass of patients the pseudotuberculous. Its worth will be recognized also if it establishes in the true types an exact topography of the lesions, follows their development, gives information on the innumerable complications which may arise, and furnishes as well useful indications for Forlanini's treatment in those who are beyond purely medical treatment.

It is not to be assumed that the radiological diagnosis of tuberculosis is to displace clinical examination and auscultation. Radiological examination may often be useful, but may often give no indication. It is not infallible. Certain light, disseminated lesions, insufficient to change the density or the elasticity of the parenchyma may perfectly well pass unnoticed. The radiologist when not taking into account clinical methods of examination may very well

declare a case of incipient tuberculosis with apparent signs on auscultation to be non-tuberculous. But the same is true of the physician who has relied wholly on clinical methods.

That is to say, radiological examination is open to the same mistakes as all other methods of investigation, but there are cases where radiological examination may prove of value, so that a physician is unwise to deprive himself of the information obtained from this new source. To make useful the radioscopic study of pulmonary tuberculosis it is not necessary to study separately each of the many forms which are met with in the clinic. Three distinct groups only will be considered:

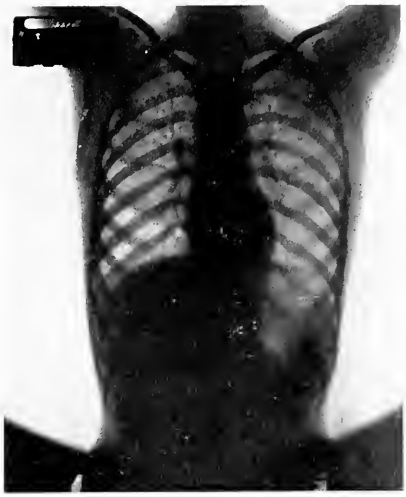
a. Pulmonary tuberculosis without clinical or stethoscopic signs. (Latent forms.)

b. Pulmonary tuberculosis with clinical signs but stethoscopic signs negative, doubtful, or very limited. (Early forms: Period of incubation. Miliary.)

c. Advanced pulmonary tuberculosis with evident clinical and stethoscopic signs. (Chronic pulmonary tuberculosis with its many forms.)

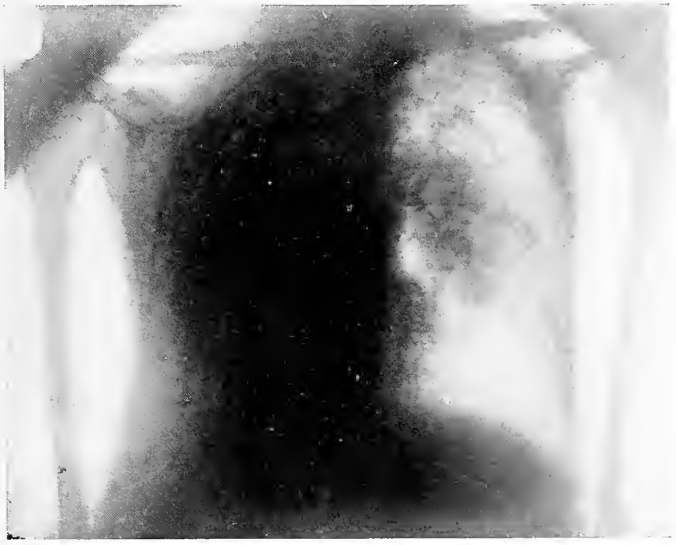
Pulmonary Tuberculosis without Clinical or Stethoscopic Signs.—(Latent forms.) The latent forms of pulmonary tuberculosis are common. As they give no chest symptoms, either physical or clinical, they often remain undetected.

Sometimes these latent forms, instead of giving respiratory or chest symptoms, affect instead quite another organ. Sometimes the general health alone is affected. Patients grow steadily thin, lose strength and appetite without apparent cause. Otherwise there is neither cough, expectoration, nor shortness of breath. Auscultation of the chest does not reveal any change of the vesicular sounds. At times the disease takes the form of anemia or of chlorosis, evident by increased pallor, palpitation, shortness of breath, and especially nervous condition. At other times the digestive tract is affected, as evidenced by dyspepsia with a



RADIOGRAPH 36. BILATERAL PULMONARY TUBERCULOSIS WITH RAPID PROGRESS

No. 227. L. D. Female, 14 years old. Chronic active bilateral pulmonary tuberculosis. Typical clinical history and physical findings: Dullness. Râles.



RADIOGRAPH 37. EXTENSIVE TUBERCULOSIS OF THE RIGHT LUNG WITH CAVITIES AT THE APEX

Total obscurity of entire hemithorax with clear zones (hardly visible on examination) at the apex. At the left, extensive shadow at hilus region with scattered mottling. Clinical signs—cavernous respiration at the right apex very extensive. In the lower half abundant, moist, gurgling râles, purulent expectoration, numerous Koch bacilli. Onset nine years ago with hemoptysis. At present, bilateral lesions; infiltration in mass of the whole right side with disintegration and cavities. Partial dextrocardia.

heavy feeling, slow, painful digestion, loss of appetite, sometimes vomiting, continual loss of weight. At times, too, these patients appear like neurasthenics in a state of lassitude, depression and great discouragement. Unless these facts were as well known as they are now, nothing would attract one's attention to pulmonary tuberculosis, as the most careful auscultation often remains negative. The clinician in these cases has often to resort to other methods for information and among them—aside from the valuable laboratory tests (serum, ophthalmic, and skin reaction)—radioscopic examination should naturally be included.

There are a certain number of latent forms of tuberculosis which give absolutely no signs, although those affected appear in perfect health. They are the old, cured tuberculous cases with well defined lesions, the progress of which has gone on often entirely unnoticed. These facts have been well known ever since Laënnec demonstrated the frequency of these cicatricial lesions in autopsies. All clinicians have observed them, either under the form of fibrous cicatrix, cretaceous tubercle, small caseous centers enclosed in a fibro-calcareous covering, or under the form of glands having undergone caseous or calcareous degeneration. All these lesions, clinically absent, may be demonstrated by radioscopic examination, which shows the existence of a previous attack of tuberculosis until then completely ignored.

Pulmonary tuberculosis, often appearing slight and incipient in a patient will be proved by radioscopic examination to be more extensive and secondary to a previous attack. The frequency of radioscopic changes in pulmonary pictures of hospital cases is very great. Kelsch and Boinon, in a military hospital accepting only selective cases of young men, found these pulmonary changes 51 times out of 124 patients examined, that is, 41 to 100. They do not assert that all these anomalies are of a tuberculous nature, but undoubtedly a good number of them must be. In a civil hospital receiving patients of all ages with a more severe

pathological past the frequency of these anomalies is still more marked.

The study of these abnormal shadows either at the apex or in a limited portion of the lung, in the hilus area, interlobar fissures, and costodiaphragmatic sinuses will often assist us in detecting these latent forms and in ascribing to their true cause diseases which from the abnormal appearance would have been difficult of interpretation.

Pulmonary Tuberculosis with Clinical Signs but Stethoscopic Signs Negative, Doubtful or very Limited.—(Early forms. Period of incubation. Miliary.) This class includes all patients who show clinical signs, functional troubles affecting the respiratory tract, but whom the negative or doubtful stethoscopic examination will not allow us to class as tuberculous, such as young people who grow thin, have intermittently a small, dry cough without expectoration, which is commonly classed as a nervous cough. They easily get out of breath and on the least exertion have an increased pulse rate.

There are, too, habitual coughers, who in general good health, have so-called repeated prolonged colds, grippe in all its forms without, however, having any precise localization discernible on auscultation.

There are the incipient tuberculous cases with doubtful stethoscopic signs or intermittent signs appearing and disappearing from day to day, passing from the right to the left apex, consisting of slight changes in the vesicular sounds without abnormal sounds or râles. In all these patients attention is drawn to the respiratory tract, but one cannot state that it is tuberculosis. These are doubtful cases.

Careful radiological examination here may be useful and help in dispelling doubt one way or another. Examination must be made methodically and should include the apices, hilus, interlobes, form and dimensions of the thorax, direction and displacement of the ribs, and respiration.

Examination of the apices.—This examination ought to be made with most minute care and after taking all possible

precautions. Both the radioscope and the radiograph should be used.

Radioscopy.—Radioscopic examination of the apices ought to be made under the best possible conditions of light, with a well regulatable tube, so that the quality of the rays can be varied in such a manner as to get every detail of shadow. Normally, the apices are less clear than the bases; the bony rigid cavity in which the lungs are enclosed hinders expansion of the upper part so that the air penetrates in smaller quantity and their clearness suffers thereby. However, their transparency remains sufficient for the contour of the ribs and clavicle to stand out clearly. Apart from this pathological state, it is very important to know that the clearness of the apices varies exceedingly with individuals. Thin and poorly nourished patients show a very perceptible transparency of the apices, while in obese and very muscular patients the apices become obscured and uniformly gray. It is not necessary, then, to attach absolute value to a diminution of equal and symmetrical clearness on both sides. A comparison of the pictures of the two apices taken from the anterior as well as from the posterior position is necessary, and to do it well it is essential to limit the light exactly to the region of the apex by means of a lead diaphragm.

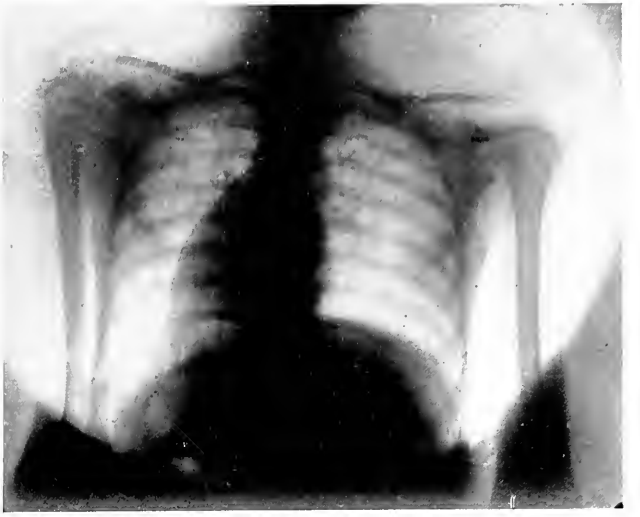
Far more important is the ascertaining of a unilateral obscurity resulting from this comparative study; yet even in this case, conclusions must not be hastily drawn.

First of all, it should be determined whether this unilateral obscurity is indeed of pulmonary origin. To do so the patient must be examined to see whether this lack of clearness may not be caused by an anomaly of the skeleton, a malformation of the clavicle, or scapula, or by a scoliosis. Sub-clavicular fossæ must be carefully palpated to see whether some gland may not be the cause of this. The thyroid gland ought to be examined, as a goitre scarcely apparent is enough to produce the difference in clearness of the apices. In fact, the neck ought to be carefully gone over. When no other external cause is a factor, use should be made of the clinical

information. If stethoscopic examination is negative, no conclusion can be drawn, but if some doubtful or intermittent signs are heard, it is necessary to compare the findings. If they do not agree, if the doubtful auscultatory signs appear on the right side, for example, while the radioscope shows a diminution of clearness of the left apex, one must be careful in drawing conclusions. If the findings are alike in the two methods, the probabilities will become almost a certainty.

In this case only a slight difference of shade, almost doubtful, exists between the two apices. If the shadow is much more marked, not homogeneous, and darker spots appear on the general gray shade, the radioscopic information in itself takes on greater value. But it may be that the radioscopic examination shows nothing, that the most careful study discloses no appreciable difference between the clearness of the two apices. Even then the lungs cannot be declared sound, for there may perfectly well exist questionable lesions, disseminated tubercles, incapable separately of furnishing a radioscopic picture appreciable to the eye. But the radiograph, however, is still useful in completing this study.

Radiography.—The radiograph gives greater depth to the picture than does the radioscope. The very perceptible decrease of sharpness in the radioscope makes it impossible for us to see on the screen the fine detail of structure and half-tones which we, on the contrary, easily read on the negative examined in full light. For a long time the radiograph was neglected in studying the lungs on account of the technical difficulties, the principal of which was the length of exposure. To-day in well equipped laboratories one can reduce the length of time for taking radiographs to the fraction of a second, especially with the aid of the new intensifying screens. In this way immobilization of the lung is complete and pictures are obtained in which the finest detail in structure appears. Thus very small initial lesions which it would be impossible to see on the radioscopic screen are demonstrated.



RADIOGRAPH 30. INCIPIENT TUBERCULOSIS. RADIOSCOPIC SIGNS MORE IMPORTANT THAN THE CLINICAL

An opaque, rounded shadow approaches on the right the median shadow above the auricle. Obscurity of the right apex already well marked. Abnormal shadows are present in the upper half of the pulmonary fields on both sides. Clinical signs very slight and limited to the right apex. No modification of sonorousness. Slight increase in fremitus and diminution of the vesicular sound. Some small, intermittent râles after coughing, in the sub-spinous fossa. Nothing on the left. The radiograph indicates tuberculosis of the tracheo-bronchial glands on the right. A very appreciable obscurity of the right apex and quite extensive shadows in both lungs.

RADIOGRAPH 31. "TUBERCULOSE SCISSURALE" ON THE RIGHT IN A CHILD

Transverse opaque band at the level of the right interlobe. The lower border of this shadow is clearly defined while the upper border is blurred and indistinct. Pulmonary tuberculosis is well developed especially on the side of the upper lobe.

To obtain good results a radiograph of the apices should be taken and not of the whole thorax. A cylindrical cone and tube not too hard (6° B.) will give more detail. The patient should be on his back and well immobilized with the radiographic frame beneath the shoulders so that they are symmetrical and in close contact with the frame. The negatives obtained with these precautions show the slightest abnormal shadows and the exact structure of the apices.

Examination of the hilus.—After the study of the apices, attention should be directed to the hilus of the lungs. In studying normal pictures it has been shown that the shadow of the hilus is somewhat crescent shaped and elongated, situated at the edge of the median shadow and separated from it by a narrow band. The convex side of the crescent is turned towards the median shadow. The two points are unequal in length. The upper point is short, while the lower one is longer and projects into the lower third of the pulmonary field. This lower horn is visible only on the right, while on the left it is covered by the cardiac shadow. This hilus shadow is distinguished clearly in the normal and always remains somewhat light. In tuberculous patients the shadow of the hilus is very often modified in an early stage. There are even cases in which tuberculosis of the hilus precedes pulmonary tuberculosis. This mode of onset in children is admitted by a large number of clinicians. In adults it is much disputed. Rieder and Rosenthal of Munich have drawn attention since 1908 to the frequency of this mode of onset.

Whatever opinion may be held on this subject, radiologists generally agree upon this one fact, that the hilus shadow is abnormal at an early stage in tuberculosis. This condition is seen by an increased opacity of the shadow, which becomes more visible and less homogeneous, by the disappearance of the narrow band of light separating it from the median shadow, by its central enlargement and the elongation of the points, which cause the crescent form to disappear.

The deformation is not regular; it predominates sometimes in the upper point, sometimes in the lower. These hilus changes have a very great value. Undoubtedly their presence does not signify absolutely that tuberculosis is present. Many bronchial and peribronchial inflammations, non-tuberculous, may produce them. It is commonly found in children, following whooping-cough, measles, or simply grippe. It may appear in the adult in a number of affections involving the mediastinum, œsophagus, or even the stomach. It has not anything pathognomonic, but its occurrence in a patient with suspected tuberculosis has a very great value. Radioscopic examination, principally in the frontal position, is sufficient in general to show them, but the radiograph establishes this picture for a more careful study of their exact form, structure, and the direction of inflammatory irradiations which may be produced on the side of the lung.

Examination of the interlobes.—It is important to ascertain carefully the condition of the interlobes in patients suspected of tuberculosis. Often the onset occurs in an interlobar fissure and then extends to the corticalis of the adjacent pulmonary lobes ("tuberculose scissurale"). The affection in this case seems to begin in the middle portion of the lung. This mode of onset is rather common. Barjon and Péhu have often met with it in children. Barjon has also seen it several times in adults.

A somewhat opaque, obscure band is shown by radioscopic examination to cut transversely the hemithorax in its entire width at the level of the interlobe. This band is more or less wide according as the pulmonary lesion is more or less extensive, the extension taking place on both sides of this band into the adjacent lobes. The more the lung is affected, the lighter the contours of the band become. Diagnosis of interlobar pleurisy is made by radiological and clinical methods. The radioscopic picture is less distinct and does not show the distended edges clearly separated from the interlobar mass. Clinically the development of the "tuberculose scissurale" is somewhat insidious.

Often it gives no stethoscopic evidence, nor the high temperature and the serious functional troubles which ordinarily accompany suppurative interlobar pleurisy. This fissure form of tuberculosis is most often discovered on radioscopic examination only.

Examination of the thoracic cavity and heart.—The form and dimensions of the thoracic cavity are usually modified in the tuberculous on the side affected. This modification may be early and attract attention in patients whose lesions are still not very extensive and give no sure signs. These deformations are found both in patients with latent and inactive lesions and in patients who have had previously a benign pleurisy which has gone on undetected.

Radioscopically they appear as a narrowing of the pulmonary field; on the diseased side the hemithorax is narrower than on the normal side. At the same time the ribs slant considerably downward and outward and are nearer one another, the intercostal spaces being narrowed. This appearance is quite characteristic, but when it is found, there already exist as a rule definite lesions. Only exceptionally can it be regarded as an early sign.

The examination of the cardio-vascular system is more important. The tuberculous have usually a small, median heart, projecting a very little to the right or the left of the median shadow. Destot some time ago drew attention to the value of this sign. It is certain that it is rare to find a large heart in the tuberculous and this fact ought to be taken into account. The small, median hearts show, if not tuberculosis, at least a predisposition to it. On the contrary, the existence of a large heart in an individual suspected of tuberculosis ought to be interpreted in a favorable manner. If a certain negative argument cannot be made against the existence of tuberculosis, it will be concluded that at least the patient has a greater resistance and gives a less favorable field to the development of the disease.

Study of respiration.—It is quite otherwise with the study of respiration, which often has very great interest from the

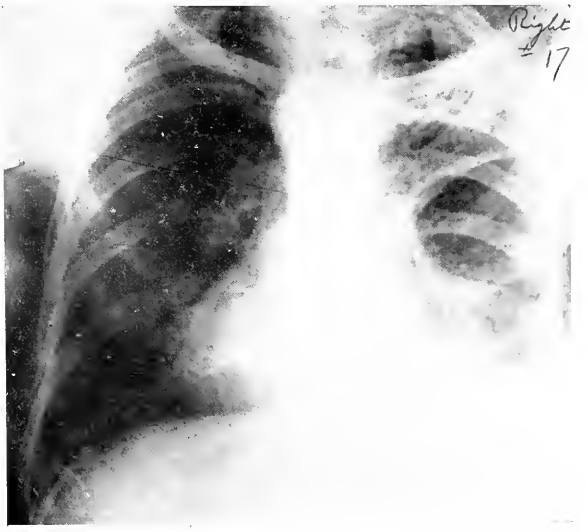
point of view of early diagnosis. Normally the dome of the diaphragm is clearly seen on the screen to rise and fall regularly through a somewhat extensive excursion and alike on both sides. In incipient tuberculosis careful examination and exact measurements often show early modification of respiration of the side affected. During expiration the two diaphragm domes rise to the same level, but in inspiration their excursion becomes unequal. The lowering of the diaphragm is less on the diseased side and the difference of the level between the two sides of the diaphragm is at times important.

Authors have explained this phenomenon differently. Some believe in the pleural theory, others in the pulmonary theory. The advocates of the first admit that, the early lesions being often superficial and sub-pleural, there is instantly produced a somewhat active reaction on the serous surface, which, by a form of secondary paresis, helps to reduce the movements of the diaphragm. Those who hold the second theory are of the opinion that the restricted initial lesions, even when questionable disseminated tubercles are present, and all the more when they are numerous and confluent, are sufficient to reduce in a marked degree the pulmonary elasticity. As a result of this the respiratory capacity of the lung affected is perceptibly decreased so that the air enters it in a much smaller quantity, and consequently the excursion of the diaphragm is diminished.

This sign, when it is present, is of great value from the point of view of early diagnosis, especially if it coincides with a diminution of the clearness of the apex and a modification of the shadow of the hilus on the same side, but it must be borne in mind that this is often lacking even when unquestionable pulmonary lesions already exist. In fact, and in spite of everything, early diagnosis of incipient pulmonary tuberculosis remains one of the most difficult clinical problems. Radiological examination does not eliminate this difficulty, but it should never be neglected because it is especially in the difficult cases that the most information

RADIOGRAPH 32. RIGHT PULMONARY TUBERCULOSIS STARTING FROM THE FISSURE (IN A CHILD)

A broad, dark band occupies the entire middle part of the right lung leaving a clear zone at the apex and another at the base. The edges of this band are blurred and indistinct on both sides. Pulmonary tuberculosis has extended almost equally into the two adjacent lobes on each side of the fissure.



RADIOGRAPH 33. PULMONARY TUBERCULOSIS BEGINNING IN THE LOWER PORTION OF THE UPPER LOBE OF THE LEFT LUNG AND THE INTERLOBAR FISSURE

No. 17. O. H. Male. Age 24. Clinical examination: Pulmonary tuberculosis, chronic, active, all right lobes. Pleurisy on left. Question of fluid.
X-ray examination: Fibrosis of right lung, marked at right apex. Thickening of interlobar pleura and diaphragmatic pleura. Emphysema of left lung.
Diagnosis: Tuberculosis right lung.

should be obtained. It cannot be concluded from a negative examination that the lung is perfectly sound. Positive facts alone in medicine have an absolute value. Radioscopic examination by disclosing slight modifications of clearness, by localizing these modifications where clinical examination has suspected them, will give the clinician either certainty or much greater assurance.

Two other forms of tuberculosis may be included in this second group: miliary and infant tuberculosis, because they both give almost no stethoscopic signs and clinical diagnosis is often difficult.

The miliary form is at times only an ultimate step in the confirmed tuberculous patient. It passes unnoticed, masked under the more or less pronounced symptoms of the disease. When it is primary, clinically it sometimes resembles gastric disturbance or typhoid fever. The thoracic symptoms are often lacking or appear only at a later stage.

During the last few years several radiologists are said to have succeeded in establishing the diagnosis of the miliary form by means of instantaneous radiographs showing the existence of pulmonary granulations. This has not been verified by Barjon.

Tuberculosis of infants has been the subject of a very interesting work by Ribadeau-Dumas, Albert Weil and Maingot (Société de Pédiatrie, 1912). These authors, by the aid of instantaneous radiographs, have confirmed the theory of Rist and Ribadeau-Dumas showing that tuberculosis of infants ordinarily begins as a small focus in the lower lobe, then attacks the glands of the hilus, then the tracheo-bronchial glands, and affects the apices only subsequent to these gland lesions.

Pulmonary Tuberculosis with Definite Clinical and Stethoscopic Signs.—In this class must be included all the many forms of chronic or sub-acute pulmonary tuberculosis. In all these cases clinical diagnosis has been made. The greater number of these patients show evident clinical and stethoscopic signs: general state of health poor,

loss of weight, fever, sweating; cough, shortness of breath, hemoptysis, purulent expectoration; moist gurgling râles, bronchial breathing, cavity signs. Radiological examination is used simply to confirm diagnosis. Cases of pseudo-tuberculosis often occur among these patients and it is important to distinguish it from true tuberculosis because it is curable. Radiological examination will at times be of great help in differentiating them when it cannot always be done in the clinic alone. In true tuberculosis the topography and extent of the lesions can be better determined by it than by clinical examination and prognosis established. Finally, it will help in studying the development, in disclosing the complications often unnoticed but frequent in tuberculosis, and even in furnishing therapeutic indications.

Radioscopic appearance of the thorax in a confirmed tuberculous patient.—Nothing is more variable than the radioscopic appearance of the thorax in confirmed tuberculous patients. Everything may be seen from the most questionable shadows to the most absolute opacity, from the most limited obscurity to total involvement of the entire hemithorax or of both pulmonary fields. The most unexpected localizations and forms may be established. Briefly, it is impossible to give an exact and precise description, yet it is possible to point out a certain number of general characteristics which are constantly seen by radioscope and which may serve as a guide in the study of tuberculosis.

The abnormal shadows which are seen affect most often the region of the apex and hilus. When they are more extensive, these regions are usually more opaque. In general, the shadows are scattered, varying in density, and separated from one another by clearer spaces. The term "mottling" (pommelures) which is commonly used is that which best describes this appearance. Tuberculosis develops through foci. In confirmed cases of tuberculosis abnormal shadows are almost always found on both sides but generally predominating on the side first affected. In advanced cases

the abnormal shadows gradually reach the lower portions of the lungs while the apices are spotted secondarily with clear rounded zones more or less regular in appearance, corresponding to cavities made in the disintegrated parenchyma.

The many complications which arise in the course of the development of these tuberculous cases usually give rise to modifications of these data. Congestive attacks, centers of pneumonia or broncho-pneumonia, pleurisy of the large cavity, or encysted pleurisy give rise continually to new pictures whose interpretation is useful and interesting.

Pseudo-tuberculosis.—Clinically there are a good many non-tuberculous patients who may at any time give symptoms of confirmed tuberculosis. They are generally chronic patients who have been coughing and expectorating for months and at times even years. They have lost weight, appetite and strength, are even cachectic, have profuse sweating and fever. Their cough is accompanied by shortness of breath, purulent expectoration, sometimes hemoptysis. Auscultation of the thorax shows evident and even extensive stethoscopic signs, labored respiration, moist gurgling râles, cavity signs. Sometimes the general health remains good but the auscultatory signs are so marked and persistent that they suggest a center of pulmonary tuberculosis. These patients are affected at times with purulent, encysted pleurisy, interlobar or otherwise, sometimes with abscess of the lung, cancer of the lung, hydatid cyst of the thorax, pulmonary syphilis, dilatation of the bronchi, actinomycosis of the lung, etc.

Fairly often clinical examination alone, the study of the development, an examination of the sputum and, if need be, inoculation, will suffice to detect these pseudo-tuberculous cases, but very often this is insufficient and it is of great importance that it be determined earlier because immediate intervention may save these patients.

Béclère has reported a case of a child of five years of age who for a long time was throught to be tuberculous, in whom

radioscopic examination disclosed finally the presence of a suppurative interlobar pleurisy. The child succumbed in spite of intervention because it was too late.

In the chapter on interlobar pleurisy Barjon has pointed out a patient who entered his service as tuberculous, who for seventeen years had an empyema which was incompletely emptied by vomica. The patient remained a chronic cougher, had purulent expectoration and hemoptysis but was cured by surgical intervention.

Radioscopic examination is therefore important, as this patient showed the lung to be sound and a definite pleural collection to be localized at the level of the interlobe. The idea of tuberculosis was in this way definitely discarded.

Barjon examined at home with a portable machine a patient who had a cough and fever for many months and was reduced to a state of great emaciation. He was considered an advanced and incurable case of tuberculosis. A relative of the patient insisted on a radioscopic examination. Barjon found at the base of the lung a defined oval shadow, with contours well limited, while the rest of the lung was perfectly clear with nothing abnormal at the apex. Lung abscess was thought of and surgical intervention advised. The surgeon two days later found a purulent intrapulmonary collection, emptied and drained it, and the patient had a perfect recovery.

Early cancer of the lung is at times difficult to diagnose. The patients become thin and cachectic, cough and have frequent hemoptysis. Examination of the thorax shows stethoscopic signs localized at the apex, for early cancer of the lung usually affects the upper lobe. This disease also often assumes the appearance of tuberculosis. The radioscope is one of the means at the clinician's disposal to correct his diagnosis. Examination on the screen shows the abnormal shadow more homogeneous, more limited, less diffuse than that of tuberculosis. In the tuberculous with a shadow at the apex there follows a series of uneven mottlings which infiltrate in a diffuse manner the pulmonary parenchyma

RADIOGRAPH 34. CHRONIC SIMPLE BILATERAL TUBERCULOSIS—DISINTEGRATION AND CAVITY LESIONS

The two pulmonary fields are studded with diffuse shadows—a mottled appearance. A somewhat clear zone at the right apex—the supra and sub-clavicular region (cavity). Autopsy.—Diffuse pulmonary tuberculosis of the suppurative broncho-pneumonic form. The right lung shows a large cavity which occupies the entire upper lobe. Disintegrating and cavities in the middle lobe; infiltration of the lower lobe. Diffuse sclerosis. The left lung shows disintegration and many small cavities in the upper lobe; infiltration of the lower lobe.

RADIOGRAPH 35. PULMONARY MYCOSIS SIMULATING TUBERCULOSIS

A somewhat extensive obscurity of the right apex with a clear zone (cavity). Less extensive obscurity of the left apex. Clinical development—fistula in the thoracic wall of the pulmonary cavity. Metastasis in the calf of the leg. Laboratory examination shows that it is a mycosis and not tuberculosis.

without any definite lower outline. The opposite apex almost always shows some anomaly. In early cancer the shadow is more clearly defined by the interlobe; the line of demarcation is clear; below, the lung remains clear, the opposite apex is normal.

Such are the radioscopic findings that are to be relied upon. Barjon found them in precise form in two cases, but perhaps they will not always be as clear.

Another patient with the diagnosis of pleurisy and congestive attacks of the apex with hemoptysis showed on radioscopic examination the existence of an hydatid cyst of the thorax with its characteristic picture, regularly spherical with contours well demarcated. The apex showed no other abnormal shadow. It was only a little lighter, compression diminishing its elasticity and respiratory capacity. Surgical intervention confirmed the diagnosis and cured the patient.

Patients affected with dilatation of the bronchi often pass as tuberculous. Clinical diagnosis is ordinarily made because of the slowness of development, preservation of general good health, localization of the stethoscopic signs towards the bases, the absence of Koch's bacilli in the sputum. Tuberculosis when occurring at the bases should always be treated with suspicion. Radioscopic examination may be useful. In dilatation of the bronchi there are present only very questionable abnormal shadows, a little diffuse obscureness towards the bases but no characteristic picture. There is a contrast between the abundance and the intensity of the auscultatory signs and the slight opacity of the region. True tuberculous lesions give denser shadows; and when a contrast does exist, the auscultatory signs are rather reversed, that is to say, there appears on the screen an area relatively much darker, in which auscultation gives much fewer signs.

Pulmonary syphilis in some cases may also simulate tuberculosis. Béclère in 1911 and Bensaude and Émery in 1913 (à la Société médicale des hôpitaux) demonstrated the part of radiological examination in these cases. It establishes, on the one hand, the presence of abnormal shadows and, on

the other hand, follows their progressive and rapid disappearance under specific treatment. Barjon followed on the screen a patient of Dr. Paul Courmont affected with pulmonary mycosis. Radioscopic examination showed a diffuse shadow at the apex somewhat like that of simple tuberculosis. At the end of some time a cavity was formed in this apex. Its presence was evident both stethoscopically and radioscopically. Everything pointed to tuberculosis, but the examination of the sputum for Koch bacilli was constantly negative and doubt persisted. Diagnosis was made later by the appearance of a metastasis in the calf of the leg; in the pus characteristic yellow granules were found and microscopic examination showed the specific parasite.

As a result of the cavity at the apex, a fistula formed under the skin in the supra-spinous fossa, confirming the diagnosis of mycosis of the lung. In this case the radioscopic examination furnished no information which could indicate the true diagnosis.

In spite of this exception, pseudo-tuberculous or abnormal tuberculous cases ought to be submitted to radiological investigation. In the great majority of cases valuable indications will result from this examination which will correct diagnosis and ascribe to their true cause chronic pulmonary affections which assume in their progress, symptoms, and development, the appearance of tuberculosis.

Topographic study of the lesions in tuberculous cases.—In confirmed tuberculosis, radioscopic examination has no part in establishing diagnosis, but it is very useful in determining the topography and extent of the lesions. Nothing is so deceptive as stethoscopic examination from this point of view. Often deep, extensive lesions covered over by a portion of sound lung have given no evidence on auscultation. As a general rule, after a tuberculous patient has been carefully examined and the topography and the extent of his lesions have been carefully determined, the radioscopic screen will, in the majority of cases, reveal lesions more extensive than suspected. Inversely, when a tuber-

culous patient enters the hospital at the height of exhaustion, with fever, violent attacks of coughing, abundant purulent expectoration, auscultation gives coarse moist râles over a large area, sometimes generalized, and the impression is that there is an extensive softening of both lungs. In this case radioscopic examination shows, on the contrary, an opaque area, sometimes rather limited, while the rest of the lung has retained its transparency in spite of the many coarse moist râles found there.

The immediate prognosis in this case is very different, for it is a primary tuberculous focus which may be of long standing and which, under fatigue, has become the starting point for a diffuse bronchial attack, intense, with abundant secretion, bronchial involvement, moist râles, purulent expectoration, fever, sweatings, etc. Some days rest in bed is enough to confirm the radioscopic examination. The inflammatory attack subsides, the bronchi empty themselves, râles disappear, fever falls, and there are no longer any stethoscopic signs except in a limited portion corresponding exactly to the old primary lesion which was demonstrated on the fluoroscopic screen.

It has been shown that in early tuberculosis, radiological examination is never infallible. Sometimes auscultation is first in importance, sometimes the radioscope. There may be a clearly visible shadow when nothing is heard, or evident auscultatory signs may exist when the screen shows nothing abnormal. There is therefore no accurate rule from the point of view of early diagnosis. (See Radiographs 29 and 30.)

It is quite otherwise from the point of view of prognosis and the appreciation of the extent of the lesions in confirmed tuberculous cases. Here the radioscope is clearly superior to auscultation and it is to indications obtained by it that the greatest importance should be attached.

In confirmed tuberculosis, if there is a disagreement between the findings obtained by auscultation and the radioscope, the greater importance should be accorded to

the latter. If, for example, only some scattered râles are heard on auscultation while the screen shows diffuse, extensive obscureness, the prognosis is bad. If, on the contrary, pronounced and extensive auscultatory signs are present while the radioscope shows the pulmonary field has retained for the most part its transparency, prognosis is less grave—at least for the present.

Study of the development of lesions in tuberculosis.—It is very interesting to follow the development of lesions in the tuberculous patient, to see them contract and become cicatrized or, on the contrary, extend and become caseated and soften. To observe this, patients are regularly examined, and the changes in physical and functional signs which have any bearing on the study of the underlying lesions are followed by palpation, percussion and auscultation.

A radioscopic examination of a tuberculous patient is not limited to a single time to confirm diagnosis and to judge of the extent of the lesions. It is, on the contrary, very instructive to continue to make radioscopic examinations almost as often as auscultation to compare the difference from time to time. A study therefore can be made at the same time by both methods of the development of the lesions in one sense or another, and useful indications can be drawn for prognosis and treatment.

When a tuberculous center is healed, it is not seen to disappear on the radioscopic screen; it persists even when completely cicatrized. The abnormal shadow indicates always the site of the healed lesions, although auscultation has been negative for a long time. The process of healing can however be followed on the screen. If the abnormal shadow does not disappear, it is reduced: the inflammatory zone which surrounds it and makes it appear larger and more diffuse disappears. The contours become more clearly demarcated. At the same time the abnormal shadows produced by the inflammatory process adjacent to the bronchial and peribronchial glands become lighter, or even

RADIOGRAPH 38. PULMONARY TUBERCULOSIS WITH VERY SLOW PROGRESS (30 YEARS), SCLEROTIC TENDENCY

Total obscurity of the right apex with a clear zone—cavity. Very dense shadows in the region of the hilus on both sides. Small scattered, very opaque spots. Development—began at twenty-two years with bronchitis. Attack of tuberculous broncho-pneumonia at thirty-three years. Slow progress with periods of remission. Died at fifty-three years of age. Autopsy—right pleural adhesions. Right lung—induration of the apex with old cavity outlined by rigid calcareous walls. Œdematous congestion of the base. Left lung—sclerosis and emphysema. No center of caseation. Some hard sclerotic glands toward the hilus.

RADIOGRAPH 39. UNILATERAL TUBERCULOSIS. CAVITY OF THE RIGHT APEX

In the upper part of the right lung three clear zones surrounded by dark outlines separating them from one another (cavities of the right apex). Diffuse and questionable shadows in the lower part of the right lung. Left lung retains its clearness.

disappear. The hilus shadow becomes less extensive and opaque.

On the contrary, when tuberculosis advances, the extent and opacity of the shadows already existing gradually increase and new ones are produced. The mottling becomes more marked and attacks the lower lobes. The pulmonary shadows gradually unite with the shadow of the enlarged hilus, become fused and more dense so that eventually it becomes impossible to distinguish them. At the same time that the lesions extend, they progress. By degrees they become softened and pulmonary cavities form.

Pulmonary cavities.—Professor Bouchard first suggested that pulmonary cavities could be seen on the screen. Ordinarily they are seen as clear areas, highly illuminated, situated in the middle of a dark zone. The form of this clear bubble is more or less regularly round and is limited by an opaque ring which outlines its contour and corresponds to the sclerosis and congestion which is taking place around the cavity. This characteristic circle prevents confusion with the healthy tissue persisting in the center of an infiltrated zone. However, this appearance is not always as characteristic and often pulmonary cavities discernible on auscultation remain invisible to Roentgen rays. The conditions which explain this invisibility are as follows:

First, it is a question of size and dimensions and it is certain that small cavities may pass unnoticed. In order that they may become visible they must contain sufficient quantity of air to give a clear picture on the screen; that is to say, that they obtain at least the dimensions of a walnut. The larger the cavities, the greater their chances of being seen. Next, it is a question of location. The more superficial a cavity, the more distinct it is. On the contrary, the deeper it is, the less visible. There are anterior cavities which are seen only in the frontal position and not at all in the dorsal position. Inversely, certain posterior cavities are seen only in the dorsal position. In contrast, there are cavities sufficiently large and located in such a way that they are as easily

visible in front as in back. The structure of the pulmonary parenchyma around the cavity also has a great influence on its visibility. If the cavity is surrounded by tissue showing only a low density, its clearness will readily stand out on the light shadow of this tissue. But if the cavity is surrounded by a dense tissue, is situated in front, or in back of a very opaque hepatization or caseation, the opacity of the parenchyma will neutralize the clearness of the cavity, which consequently will become invisible, for the radioscopic image is only the result of pictures furnished by the different transverse tissues.

Barjon found by autopsy two small, central cavities of the right apex the thick walls of which were infiltrated with calcareous salts. They had not been recognized either clinically or radioscopically.

Finally, the degree of fullness or emptiness of the cavity exerts considerable influence on the radioscopic appearance. A cavity filled with pus will give a uniform opaque shadow and not at all a picture characteristic of cavity. If it is empty, the clear area surrounded by a dark ring will reappear. Finally, if it is half empty, an opaque shadow below a clear area appears, the two zones being separated from one another by a narrow movable line, giving the appearance of a partial pyopneumothorax, provided the cavity is of large enough dimensions.

In 1912 Barjon performed an autopsy on a tuberculous patient fifty-six years old, in whom the unusual dimensions of the cavity and the appearance of the radioscopic image had made him think it a case of a partial pneumothorax. Thus the same cavity in the same patient may give from day to day different shadows, appear, disappear, and become modified, according to whether the cavity is filled with pus or whether the secretions have been totally or partially emptied.

Study of the complications in tuberculosis.—Lorrain has stated that pulmonary tuberculosis is only a series of pneumonias; Louis that it is only a succession of pleurisies. There is a great deal of truth in both these affirmations. So the

term "complication" used at the beginning of this chapter is not absolutely correct. In reality the many and varied pleural and pulmonary processes that are produced in the course of the development of pulmonary tuberculosis are not complications but the sequence. They are the natural reactions of the lung and of the pleura against the disease, from which there are a series of attacks of congestion, pneumonia, broncho-pneumonia and on the other hand, a series of attempts at rest and immobilization by pleural adhesions, symphyses, sclerosis, effusions, or partial pleurisies.

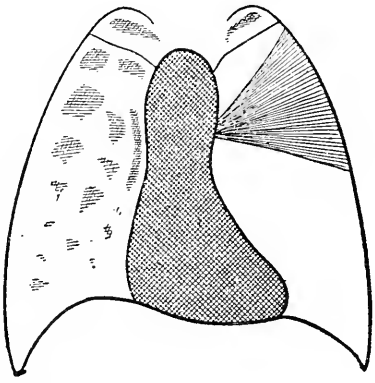


FIG. 24

Pneumonia on the left side with pneumonic triangle, in an advanced tuberculous case having lesions already pronounced on the right and more questionable in the left apex.

All these different processes, some of which are very difficult to determine clinically, give radioscopic pictures which may be sufficiently characteristic to allow of diagnosis.

Attacks of congestion are usually produced in the apical areas. They are ordinarily easy to recognize because accompanied by rise of temperature and often by hemoptysis. Radioscopically they are seen as a somewhat opaque diffuse shadow of the apex involved and if it is a question of tuberculosis which has already been observed on the screen, a perceptible difference can be noticed. The opacity is con-

siderably more than on first examination. Sometimes the radioscope serves only as a control. It is quite different in pneumonia, which, when it occurs in a fully developed case of tuberculosis, may easily pass unpercived.

It does not show the characteristics of the sudden onset of frank pneumonia which occurs in full health. On the contrary, it is seen in a febrile patient. There is lacking the onset with chill, the stitch in the side and characteristic expectoration. Radioscopic examination therefore may at times be useful in demonstrating the presence of a pneumonic process. In certain cases the axillary triangle described by Weill and Mouriquand in children may be very clearly seen. Barjon saw it in a young woman of about thirty years of age in whom the tuberculous lesions were but slightly advanced. The apical lesions appeared on the screen as scattered grayish spots and, on the other hand, the pneumonic area as a very opaque axillary triangle. Barjon also saw it in a man twenty-eight years of age who showed advanced tuberculous lesions of the right side and questionable lesions of the left apex and who had on the left side a pronounced pneumonic process.

However, in adults pneumonia does not always give the triangular figure, but may be seen as an opaque, rather extensive shadow, covering an entire pulmonary lobe. If this occurs in a well advanced tuberculous case which already shows an obscurity quite marked and somewhat extensive in the apex, the radioscopic picture is very likely to attract no special attention.

Broncho-pneumonia in tuberculous cases does not give a characteristic picture. It is seen as a series of dark spots, more or less distinct, or more or less confluent, sometimes analogous to the mottling already described, sometimes showing a more or less extensive diffuse obscurity.

Radioscopic examination is more useful in determining pleural processes, which in the tuberculous often remain unnoticed.

Pleurisies of the large cavity, which have already been treated, will not be considered again. Apart from large

initial pleurisies, pleurisy with slight effusion is met with in the tuberculous and may occur in all stages of the disease. These pleurisies are constantly insidious and unnoticed. Radioscopically, they do not always show the characteristic pictures because they occur in a pleura often abnormal on account of adhesions. Ordinarily the quantity of fluid is insufficient to produce a displacement of the heart and of the mediastinum.

The obscurities of the base which completely efface the contour of the diaphragm and the costodiaphragmatic sinus should always be suspected in tuberculosis. Nine times out of ten pleural processes are present, either simple exudates with adhesions, or effusions more or less encysted or limited. This has been verified many times by autopsy. These localizations can be made either on the side of the pulmonary tuberculous lesion, which is most frequent, or on the opposite side. An exploratory puncture will at times be useful. Encysted pleurisies, especially diaphragmatic and interlobar, are somewhat frequent in tuberculosis and difficult to recognize by clinical and stethoscopic examination.

The radioscopic study of encysted pleurisies has already been considered, as well as that of interlobar sclerosis and total and partial adhesions.

Of all the complications which may arise in the tuberculous, penumothorax is surely the one for the diagnosis of which the radioscopic examination is most useful.

In typical clinical pneumothorax with sudden onset, violent stitch in the side, intense dypsnœa, etc., penetration of air into the pleural cavity can be verified and the position of the lung determined, as well as its degree of retraction and compression and the adhesions which hold and deform it. The development of this complication can be followed and its transformation into pyopneumothorax by infection of the pleura and the formation of an effusion. This examination, made without any definite object in ordinary tuberculosis, has shown the presence of an old pyopneumothorax until then disregarded.

Radioscopic examination and treatment of tuberculosis.—The results of radioscopic examination may be useful in the treatment of tuberculosis after having furnished indications for diagnosis and prognosis. By enabling us to follow the development of the lesions, their extensive or regressive tendency, by revealing very early the existence of deep areas inaccessible to stethoscopic examination, the radioscope helps to determine the indications for a rational and medical cure of pulmonary tuberculosis.

But it is still more useful in establishing the indications and contra-indications for surgical treatment. This treatment, which consists of the application of Forlinini's method or artificial pneumothorax, has been much employed in the course of the last few years.

Aside from its great success, there have been some grave accidents and also some regrettable errors. The treatment is far from being inoffensive and the indications and contra-indications should be determined with the greatest of care.

Among the most important conditions we must take into account the following: tuberculosis must be unilateral, or at least the other lung ought to show no lesion of a progressive nature.

On the other hand, the lung to which the treatment is to be applied ought to be as free as possible of adhesions so that it may be compressed regularly and in an equal manner on all sides. Some adhesions may, as the case requires, be broken up. A total or even a partial adhesion prevents the separation of the pleura, exposes it to danger or interferes with the result.

Radioscopic examination may furnish on this subject the most interesting information, and it would actually be dangerous and even culpable to practise an artificial pneumothorax on a tuberculous patient without having previously submitted him to a minute radiological examination.

Cured tuberculous patients.—Cured tuberculosis often leaves in the lungs more traces perceptible to radioscopic examination than to auscultation. Most often very dis-

tinct and at times extensive abnormal shadows are found. They are generally localized at the level of the hilus and apices but may be found in any other part of the lungs. Often they are made up of opaque shadows with clear contours, well defined, but of small extent, corresponding to the cicatricial areas having undergone fibrous or calcareous degeneration.

What makes them more apparent is the frequent existence of a contiguous zone of compensatory emphysema, the exaggerated clearness of which contrasts with the surrounding shadow. At other times there is diffuse obscurity of the whole of one apex, corresponding to a zone of somewhat extensive sclerosis. There is added to this at times a little thickening of the interlobes, a lack of development of the costodiaphragmatic sinus, and a diminution in amplitude of the respiratory movement.

It is not uncommon to note also retraction of the thorax and ribs, and displacement of the mediastinum, aorta and trachea.

CHAPTER V

LUNG TUMORS

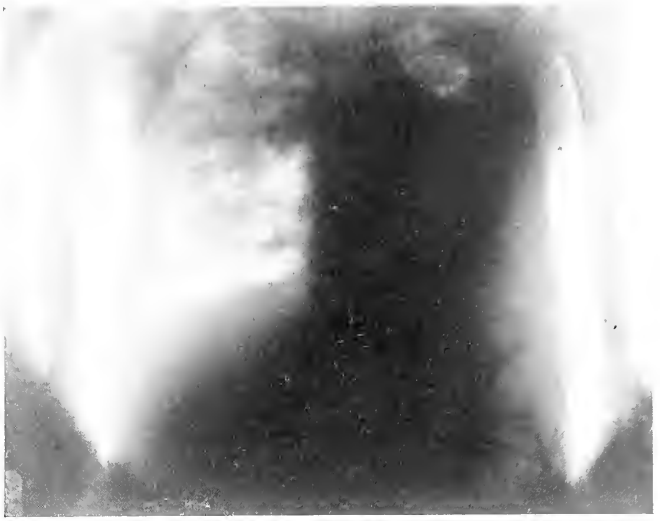
CANCER OF THE LUNG.—Cancer of the lung, appearing under variable anatomical forms (carcinoma, sarcoma, etc.) may appear clinically under very different aspects. Its diagnosis is always difficult. Radioscopic examination may in certain cases be of undisputed usefulness provided it is closely co-ordinated with the clinical findings.

In some cases only ordinary diffuse shadows are found, showing in themselves nothing characteristic. Often these shadows extend to one entire side of the hemithorax and are less opaque and less homogeneous than those produced by effusion. The opacity is sometimes less at the base than at the apex—the inverse of pleurisy—and there is no displacement of the heart nor of the mediastinum. This image arouses suspicion by its abnormal appearance. Nor does it recall the classical forms of tuberculosis. It is exceptional for tuberculosis to obscure completely from apex to base an entire lung without involving at the same time to some extent the opposite side.

These radioscopic anomalies, added to clinical anomalies in symptoms and development, make one reject the diagnosis of tuberculosis and by exclusion, suspect cancer.

But at other times certain radioscopic pictures will attract the attention by some peculiarity of form or of outline. A careful study of these pictures added to that of clinical data will at times be decisive.

Barjon had occasion to observe radioscopically seven cases of lung cancer and each time the radioscope gave very interesting indications. Three times diagnosis was made which clinically was not even suspected. Twice it



RADIOGRAPH 40. EXTENSIVE TUBERCULOSIS OF THE LEFT LUNG WITH CAVITY

Total obscurity of the entire left lung with a clear oval zone under the clavicle. On the right scattered mottled areas. Autopsy—extensive caseous pneumonia of entire left lung with large cavity under the clavicle. On the right scattered areas of tuberculous broncho-pneumonia.

RADIOGRAPH 41. PRIMARY LOBAR CANCER OF THE RIGHT LUNG

Total obscurity of the whole upper part of the right lung. The lower outline of the shadow is clear and rectilinear. The lower lobe is clear as well as all of the left lung.

definitely determined the presence of lung cancer and twice it merely confirmed diagnosis already established clinically. All these cases except one were confirmed by autopsy.

It seems necessary to preserve radioscopically the clinical distinction of primary and secondary cancer as both usually show different radiological characteristics.

1. *Primary cancer.*—This form may itself be divided into lobar cancer and cancer of the hilus, according to where it begins.

a. *Lobar cancer.*—From a radiological point of view, primary lobar cancer of the lung is characterized by a shadow in general somewhat extensive, occupying one entire lobe of the lung. The preference for the upper lobe is quite apparent. The lower part of this shadow is limited by a narrow line indicating the direction of the interlobe. The subjacent lobe keeps its entire clearness. There is, then, a clear line of demarcation between the part which has remained clear and the opaque portion of the lung. This picture has some resemblance to frank pneumonia of the upper lobe in adults. It differs, however, by a lesser opacity and homogeneousness. Diagnosis of this disease is seldom decided clinically.

Tuberculosis is more readily thought of in a patient who coughs, expectorates, has hemoptysis, grows thin, and is cachectic. The stethoscopic signs—abnormal breathing, moist râles, increased fremitus, and dullness on percussion—all point to a like diagnosis. Under these conditions radioscopic examination is very important.

In tuberculosis there is not as a rule a shadow with outlines as clear. Obscurity predominates in the apex and then extends later in a diffuse manner over the same or the lower lobes as scattered mottled areas. It is rare, when the lesions are fairly extensive, for the opposite side to be absolutely normal, and most often there are found small, localized shadows either in the apex or in the vicinity of the hilus. On the contrary, in the case of cancer, aside from some small glands of the hilus which may become affected secondarily,

the pulmonary clearness on the normal side from apex to base is persistently unaffected.

b. *Cancer of the hilus.*—Primary cancer of the lung may in certain cases begin in the region of the hilus. In the only case which Barjon observed a congenital malformation of the lung existed. The left lung, in place of being divided by a normal interlobar fissure into two lobes, upper and lower was divided by a longitudinal fissure into a short and limited hilus lobe and a large longitudinal lobe occupying

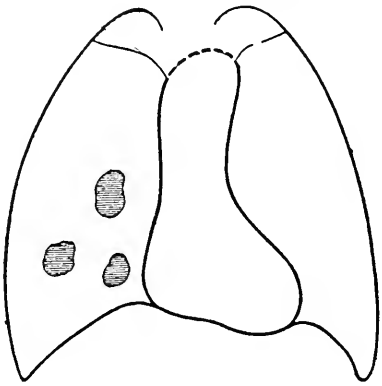


FIG. 25
Secondary cancer of the lung, nodular form, following cancer of the kidney.

the entire length of the hemithorax. This last was absolutely normal and the cancer remained limited to the hilus lobe. This case, then, comes into the category of lobar cancer.

Often cancer of the hilus region is secondary to tumors of the surrounding part—cancer of the mediastinum—and belongs then in the following class:

2. *Secondary cancer.*—This may appear under two forms: a nodular form which is quite characteristic from a radiological point of view, and a diffuse form, the radiological diagnosis of which is much more difficult.

a. *Nodular form.*—Secondary nodular cancer of the lung on radioscopic examination has a quite characteristic appearance. There is very plainly seen standing out against

the clearness of the lungs one or more shadows, round in form, with regular, well defined outline. These shadows are not very deep, but in spite of their relative superficiality, they stand out very visibly against the clearness of the lungs. They usually occur in the region of the hilus, from which they are easily distinguished by their form and their independence of the median shadow, but they may be found also right in the middle of the pulmonary parenchyma.

These neoplastic nodules are sometimes very numerous, but not all are visible. On the screen only those are clearly differentiated which have already acquired a certain size. This seldom exceeds, as a rule, 3 to 4 cm. in diameter.

This special form of secondary lung cancer is almost impossible to diagnose clinically because there are no stethoscopic signs. These neoplastic nodules are enclosed in the pulmonary parenchyma like true foreign bodies. They are easily enucleated and do not communicate either with the bronchi or with the pulmonary alveoli. They do not give any particular auscultatory sign. Being situated somewhat deep, owing to their size they do not give any dullness. All that can be observed are signs of common, diffuse bronchitis, or a small diminution in respiration when one of these nodules is localized in the region of the hilus and is able to produce a certain amount of compression of the bronchi. There is then nothing characteristic.

On the contrary, radioscopic examination makes the diagnosis instantly without hesitation. Indeed there is no other pulmonary affection which shows like pictures. Infarct of the lung, which may also be multiple, shows shadows much more diffuse, which never have contours as clearly defined nor a form so regularly round. Hydatid cysts are more opaque, more regularly spherical, and more voluminous.

This special nodular form corresponds to a particular form of epithelial cancer. In the two cases of Barjon's, it was primary cancer of the kidney of the epithelial type with large, clear cells.

b. *Diffuse form.*—Aside from the foregoing forms, from a

radiological point of view quite clearly individualized, there are others which are much less so. It is for this reason the term "diffuse form" is used to designate them.

It is a case of secondary metastasis developing usually at the base of one of the lungs. A diffuse shadow is seen occupying the whole lower part of the hemithorax and more or less completely effacing the contour of the diaphragm and the lateral cul-de-sac. There is no clear upper outline. The shadow gradually becomes effaced and is somewhat anal-

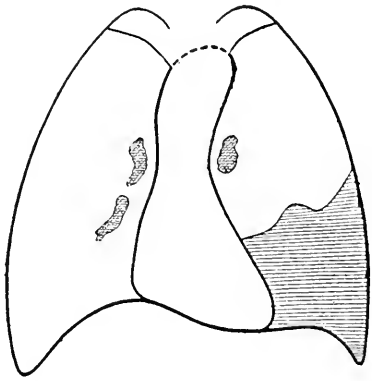


FIG. 26
Secondary cancer of the lung localized at the left base with glands of the hilus, following cancer of the testicle.

ogous to pleural effusion. The aspect differs from it, however, by the fact that the respiratory movements of the diaphragm are retained, contrary to what happens in pleurisy. There does not occur, either, displacement of the heart or of the mediastinum.

Clinically, there is dullness at the base, a diminution of fremitus, moist râles, with cavity, or even pseudo-cavity signs. Dilatation of the bronchi might be thought of, but in that case obscurity of the base is barely noticeable.

Pulmonary tuberculosis during softening or cavity formation may produce analogous stethoscopic signs. But it is exceptional for these signs to begin at the base and to re-

RADIOGRAPH 42. SECONDARY CANCER OF THE LUNG IN NODULAR FORM

In the left lung there are only diffuse shadows without exact form but on the right in the region of the hilus there are two round shadows—one especially very apparent, of regular form, perfectly detached against the clearness of the parenchyma. Autopsy—primary cancer of the kidney with secondary centers in the liver and both lungs. A certain number of pulmonary centers are very small (size of a small pea) and give no shadows. The ones visible are of the size of a large walnut.

RADIOGRAPH 43. DOUBLE HYDATID CYST OF THE RIGHT LUNG

There is very clearly seen in the right lung the picture of two superimposed hydatid cysts whose shadows, with rounded outline, overlap a little. The upper cyst is at the same time posterior. The lower is anterior. Very slight displacement of the heart and of the mediastinum. Intervention—first, the removal of the upper cyst and six months later the lower cyst (Dr. Albertin). Recovery.

main localized there. In such a case the radioscopic examination ought to bring out other disseminated shadows in the upper part of the lung and even in the other lung.

On the contrary, in the case of diffuse secondary cancer all the rest of the respiratory organs remain perfectly clear. Certain diffuse centers of common broncho-pneumonia of the base must be borne in mind. It is impossible also in this diagnosis to separate the clinical and radioscopic examination, the latter being able to add information only of secondary importance.

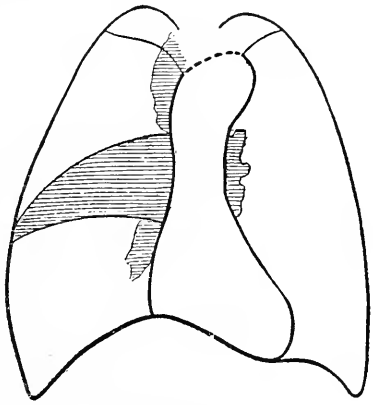


Fig. 27
Interlobar cancerous pleurisy, following tumor of the mediastinum.

In a single case, Barjon observed a very clear pulmonary shadow outline with somewhat peculiar form. It was a young man operated on the year before for a malignant tumor of the testicle who showed grave pulmonary signs of the left base. On radioscopic examination there was seen at this level an extensive shadow, marked in the upper part by a clear irregular line, raised in the middle by a rounded projection which gave to the picture the appearance of a tumor. There were rather large glands of the hilus, but the rest of the pulmonary field remained clear. Diagnosis of secondary cancer of the lung was made and subsequently verified.

Cancer of the pleura.—Cancer of the pleura offers little of interest from a radiological point of view. It is seen most often under the form of pleurisy of the large cavity with effusion. Radioscopically it does not differ from ordinary pleurisy, treated in another chapter, and it is for the clinician alone to prove its nature.

Barjon cites as a matter of curiosity a case of interlobar cancerous pleurisy which he observed in the course of the development of a mediastinal tumor. Diagnosis was made because the development of this mediastinal tumor was studied on the screen for three months and the complication thus determined.

Hydatid cysts of the lung and dermoid cysts of the thorax.—Two kinds of cysts may be found in the thorax—hydatid cysts, which are always frankly pulmonary in origin, and dermoid cysts, which arise rather in the mediastinum. These varieties of tumors are somewhat rare. Dermoid cysts are even more rare than hydatid cysts. It is important, however, to recognize them because the findings of the radiologist play a very decisive part in their diagnosis.

Their radiological characteristics being almost the same, it will suffice to indicate the particular points which may serve in establishing differential diagnosis. Very few articles have been published, in France at least, on this subject. Tuffier, in 1897 at the Congress of Moscow, in 1901 in the "Revue de Chirurgie," and again in 1910 with Martin in the same review, collected quite a number of very well studied and very interesting cases. Roncé in 1907 collected only 14 cases of hydatid cysts of the lung, 10 of which were without any radioscopic examination. In 4 cases this examination was made by Béclère.

Barjon saw a case of double hydatid cyst of the lung and a case of dermoid cyst of the thorax. They were verified surgically and cured.

Radiological diagnosis of cyst of the thorax is generally easy. These tumors show a peculiar shadow of very round

form as if traced by a compass, the contours perfectly defined and standing out with great distinctness against the clearness of the pulmonary fields. No other tumor shows such a perfect spherical appearance, yet in certain cases there may be some hesitancy. To establish a certain diagnosis three questions should be borne in mind:

1. Is it a cystic tumor?
2. What is its exact location?
3. What is its nature?

Differential diagnosis of cyst.—When the tumor is situated right in the middle of the pulmonary parenchyma and circumscribed all around by a clear zone, its regularly rounded form and its size will determine diagnosis. There is scarcely anything except secondary nodular cancer of the lung which could give analogous pictures. But the cancerous nodules are less regularly spherical, less opaque and voluminous. When the tumor approaches the median line and its shadow becomes a part of it, not being outlined except outside of the pulmonary field, an aneurysm of the aorta or a mediastinal tumor are suggested.

In aneurysm of the aorta the outlines are equally clear and sometimes very rounded. The establishment of pulsation of the wall might have a certain value but it is well known that this pulsation is often lacking. Sometimes the radiograph may show details of structure, such as uneven thickening of the wall, corresponding to calcareous plaques. But it is especially a series of oblique examinations which will eliminate all doubt, showing the close relation of this tumor to the aorta.

Tumors of the mediastinum have generally less regular outlines. Their edges are often very obscure and difficult to outline in places. They rise up sometimes high above the clavicle and finally, they are accompanied ordinarily by gland obstructions visible also on the screen.

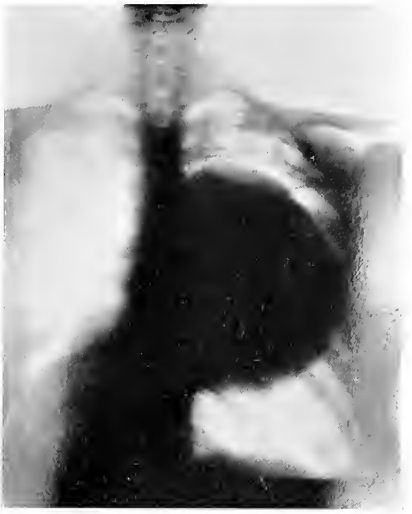
Certain cases of interlobar pleurisy with much effusion may give a picture as round and as voluminous but never showing a regularity as perfect as that of cysts. The shadow

furnished by such a collection cuts the hemithorax in its entire width, adheres to the median shadow on one side and follows up to the external wall on the other. It is not raised either above or below more than in the center. When the cyst is fairly large and occupies the lower two-thirds of the hemithorax so that it completely obscures the base, effacing the contour of the diaphragm and the pleural cul-de-sac, producing displacement of the heart and of the mediastinum, pleurisy of the large cavity might be thought of and the cyst misinterpreted.

That is what occurred in the case reported by Desmarest (Presse médicale, June 1st, 1912). There are, however, in such a case indications which ought to guide an expert radiologist. The form of the upper outline of the shadow should especially attract attention. When it is decidedly convex and shows an abnormal form or direction, not following the well-known rules of pleural curve formation (see chapter on pleurisy), the picture ought to arouse suspicion and its interpretation ought to be discussed. This same observation might allow us to make a diagnosis in the case of the coexistence of cyst and pleurisy on the same side, the picture becoming analogous to the preceding. In this case there is at times a quite appreciable difference in the contour of the shadow according to position. In the dorsal or ventral decubitus the fluid by being carried towards the apex, effaces more or less completely the contour of the cyst, which takes on its clear, convex form in the upright position.

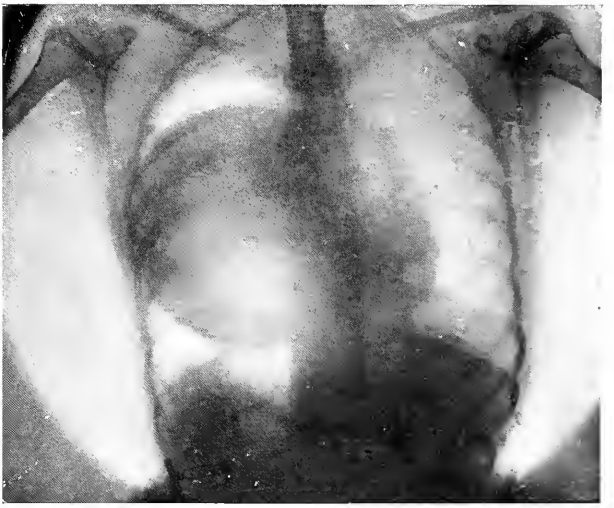
Certain tumors of the lung or of the pleura (sarcoma) may also give extensive shadows, limited in their upper part by a clear, convex, semi-circular contour, quite like a cyst. Barjon has observed an example of this quite recently.

Diagnosis of cyst localization.—The topographical diagnosis has a rather great importance from the surgical point of view. It ought to be able to show to the surgeon the exact spot where he should approach the tumor. It is



RADIOGRAPH 43B

No. 100. Tumor seen in right lung of questionable origin. Resembles hydatid cyst.



RADIOGRAPH 44. DERMOID CYST OF THE LEFT HEMITHORAX

An enormous, opaque shadow, regularly rounded, occupies all the lower part of the left hemithorax. Below a clear triangle persists at the level of the sinus. Marked displacement of the heart and mediastinum to the right. Intervention—cyst opened; elimination of an enormous amount of semi-solid, fatty substance and tufts of hair. Drainage. (Dr. Albertin.) Persistence of a fistula with slight discharge but excellent general health and perfect functional result.

useful also in elucidating the exact point of origin of the cyst, a thing particularly difficult in some cases.

Careful observation of the cyst picture taken with the patient in different positions will be very useful in this localization.

If the outline is clearer, the shadow less extensive in the frontal anterior position, for example, it can be concluded that the tumor is situated in front. A new examination in the oblique and transverse position will confirm this finding and it will only be necessary to mark out exactly to what intercostal spaces it corresponds.

It is more difficult, in some cases, to know whether it is a cyst at the base of the lung or at the convexity of the liver.

Barjon has already insisted (Revue de Médecine, October, 1911) on the great difficulty of this diagnosis. In order that it may be seen two things are sufficient:

1. That the cyst be situated as near as possible to the diaphragm, either above or below.

2. That there should not exist at the level of the diaphragm and of the lateral diaphragmatic cul-de-sac any clear space discernible on the screen in any of the innumerable positions in radioscopic examination.

In such a case we must rely on the height of the superior convex line, its mobility, the level of the deformation, the examination of the lower appearance of the liver.

The superior outline of cysts at the base of the lung is in general more elevated than that of cyst at the convexity of the liver, and if there is occasion to follow the patient for some time it is seen that this outline rises more quickly, and in some months may reach an intercostal space, but it must also be known that certain cysts at the convexity of the liver may rise as far as the third space in front. The mobility of the shadow line is much less in the case of a pulmonary cyst and may even be completely abolished. On the contrary, it is better retained, although restricted, in the case of cyst at the convexity of the liver.

The deformation is more thoracic in lung cyst; more abdominal in liver cyst.

Examination of the lower surface of the liver after inflation of the stomach may show in the case of liver cyst a lowering of the organ or the deformation of the inferior contour; but all these details have only a relative value and besides may be lacking. It must be known that in certain cases it will be absolutely impossible to make the diagnosis of localization by the simple use of radioscopic examination. The greatest attention must be paid to the clinical symptoms and in particular those obtained by auscultation of the lung. The ascertaining of râles, abnormal breathing, friction rub accompanied by coughing and expectoration will be in favor of pulmonary localization. Their absence will suggest rather a cyst at the convexity of the liver.

Diagnosis of the variety of cysts.—Radiological examination furnishes little information to establish this diagnosis, yet some secondary indications may be useful.

Hydatid cysts may be multiple, may occupy in the lung varied positions and remain completely independent of the median shadow. They usually enlarge more rapidly than do dermoid cysts. The shadow is more homogeneous, the opacity more uniform in their entire extent.

The dermoid cyst is single; by reason of its mediastinal origin it remains always adherent to the median shadow. Its position is, then, much more uniform. Its growth is extremely slow, beginning to develop about the eighteenth or twentieth year. Its shadow is less homogeneous than that of hydatid cyst. It may contain teeth, bones, tufts of hair, which may either give a visible picture or show darker zones beside clearer ones.

Finally, the clinical information—previous history, development, symptoms, and laboratory tests—can be equally utilized.

Hydatid cysts emptied by vomica.—All that has just been said applies to closed cysts, but when the cyst is open and

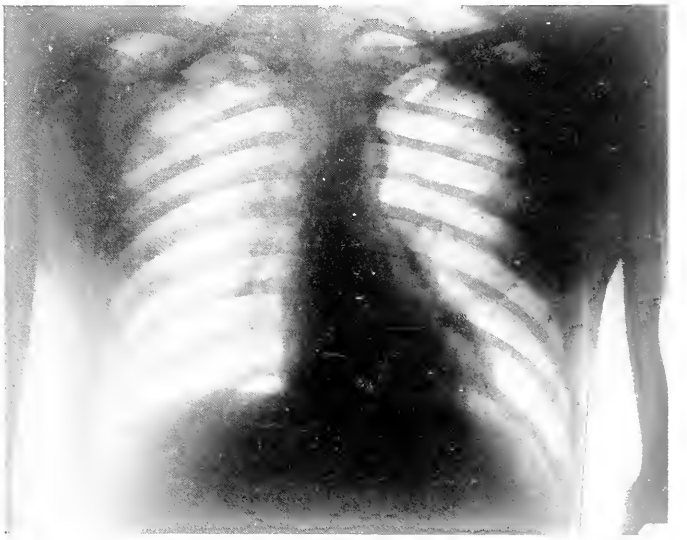
a vomica is produced, radioscopic examination has no longer so great a value. It does not furnish characteristic pictures and at times does not give any appreciable shadow. Twice Barjon examined hydatid cysts of the lung previously discharged into the bronchi and obtained from them no decisive indication. The shadows are much less opaque and have no more the characteristic spherical form. In this case, fortunately, clinical diagnosis is easy because of the previous vomica and also from the fact that from time to time these patients expectorate either pieces of hydatid membrane perfectly recognizable or entire vesicles in which one finds hydatids and their hooks.

In conclusion, radioscopic and clinical examination supplement each other in the diagnosis of hydatid cyst of the lung. When the cyst is closed, clinical interpretation is most difficult, while the radioscopic examination shows a characteristic spherical shadow which carries conviction.

On the contrary, when the cyst is open, there is no longer a clear radioscopic picture but only diffuse shadows, while clinically the expectorated material shows the origin of the pulmonary troubles.

RADIOGRAPH 45. ANEURYSM OF THE AORTA—ASCENDING PORTION

There is an extensive and opaque shadow, the rounded contour of which projects into the right lung but the other part is confused with the median shadow. The outline is not as regularly round as if traced by a compass. It is not homogeneous but shows thickening in places. It is an aneurysm of the ascending aorta, the more opaque parts which are seen on the outline corresponding to calcareous atheromatous lesions.



RADIOGRAPH 46. HYDATID CYST OF THE LEFT LUNG AFTER RUPTURE AND EVACUATION BY VOMICA

A diffuse shadow in the lower part of the left lung is discerned but there is no contour accurately outlined, no characteristic form, no spherically rounded appearance. Development—vomica took place three and one-half months ago. Since then the patient expectorates perfectly recognizable hydatid membranes but there is no longer a definite tumor; no functional trouble. Very good general health.

PART V

PENETRATING WOUNDS OF THE THORAX BY WAR PROJECTILES

CLINICAL AND RADIOLOGICAL STUDY

NEVER before has there been an opportunity to gather so many clinical and radiological reports of pentrating wounds of the thorax. The great European war of 1914, on account of its duration, extent and the tremendous effective forces employed, seems an inexhaustible source of study. These cases have allowed a clearer and more accurate study, showing at the same time the seriousness and the benignity of these wounds. It has been possible to study with greater care the symptoms, complications and development as well as the indications for operation.

The close connection which exists between radiological exploration and war surgery is to-day demonstrated. And no branch of war surgery needs a closer collaboration of surgeon and radiologist than these penetrating wounds of the chest. No wound requires a more particular and complete radiological examination.

This point especially will be taken up. No exact diagnosis can be made, no useful discussion engaged in and no conclusion reached without careful radiological examination of the wounded. This examination alone gives information as to the absence or presence of a foreign body, its topography, exact mensuration, the reaction brought about in the pleuro-pulmonary tissues, and the importance and nature of the complications developed. Only the most careful study and discussion of the facts furnished by this examination in conjunction with a competent surgeon, make it possible to show the indications and contra-indications for operation in each particular case.*

I. CLINICAL STUDY.—*1. Symptoms and diagnosis of pene-*

* The more serious wounds of the thorax with sudden death, seen only near the battlefield do not come within the scope of this study. It is limited to the wounded who can be moved to the surgical units in the rear, and whom Barjon had occasion to examine.

trating wounds of the chest.—The symptoms produced by penetrating wounds of the thorax are variable. Some appear at once, others develop more slowly.

(*a*) *Immediate symptoms.*—The first is pain, which often is not severe and is limited to sensation of shock. At other times the pain is very sharp, especially in cases of fractured ribs.

Hemoptysis is consequently one of the earliest and most constant symptoms, but may however be sometimes lacking. This early hemoptysis is due to the injury of blood vessels by the passage of the projectiles—an hemoptysis by rupture. A temporary cough may accompany hemoptysis but it too may be lacking.

Finally, the immediate dyspnœa is accompanied at times by sensations of great distress.

But all these signs may be absent and a penetrating wound of the thorax may pass unnoticed especially if there is another more apparent wound to attract attention. A wounded soldier with marked traumatism of the shoulder and arm, which required secondary amputation, was found at the end of two days to have also a penetrating wound of the chest.

(*b*) *Secondary symptoms.*—These appear during the first few days of the wound and often later. They are due to reactions brought about by the projectile in the pleuro-pulmonary tissue.* These reactions develop various physical and functional symptoms: sometimes centers of dullness with absence or with increase of fremitus, bronchial and pleural sounds, or no respiratory sounds. Associated functional disturbances are stitch in the side, dyspnœa on exertion, cough, expectoration often streaked with blood, secondary hempotysis due to the pneumonic reaction following traumatism. Tachycardia is common.

In the wound and wall there are also special signs: subcutaneous emphysema under certain conditions especially

* Piéry (Lyon Mé lical, 1914–1916) has described a hemo-pleuro-pneumonic syndrome with acute progress, which is seen quite frequently.

when there is fracture of the rib at the same time as pleuro-pulmonary injury. Sometimes there is a slight œdema of the wall which in cases of infection may end in a real inflammation of the connective tissue.

The general health is often affected indirectly; furry condition of the digestive tract, rise in temperature ending at times in a high and prolonged fever.

These symptoms taken together make possible the diagnosis of penetrating wounds of the thorax.

2. *Form, development, complications, prognosis.*—There are two principal forms of penetrating wounds of the chest: the perforating wound and the wound with one or several foreign bodies in the thorax. In the perforating wound the projectile only goes through the thorax without being arrested. Most often it is a rifle or machine gun bullet fired at close range. On account of the proximity the initial velocity and the force of penetration are greater and the projectile goes straight through the thorax without being arrested there.

This form of wound is generally less serious, and often heals very quickly without complications. The bullet is aseptic from the appreciable increase in temperature to which it is subjected on account of friction. Its pointed and regular form allows of easy penetration through the clothing so that pieces of clothing are seldom carried into the wound. Infection is more uncommon and in a great number of cases there is simply an aseptic puncture. The wounded patient quickly recovers, and at the end of two or three months nothing abnormal is found either on clinical or on radioscopic examination. The "restitutio ad integrum" is complete.

Sergeant P. of N. . . regiment of infantry, examined by Barjon, had his thorax penetrated from one side to the other by two machine gun bullets. At the end of several months he had no respiratory disturbance and radioscopic examination showed a thorax absolutely normal as far as clearness and functioning were concerned.

Sometimes there may be seen even in perforating wounds

cases complicated with fracture of the ribs or septic condition. Private C., studied by Barjon and Pollosso, showed comminuted fractures of two ribs with bone and septic fragments. He succumbed to infection of the wall and pulmonary gangrene.

In penetrating wounds with retention of the projectiles the chances of infection are more frequent. They are caused most often by bursting shell fragments. The penetrating force being less, the fragments lodge in the thoracic cavity and their irregular form easily carries into the wound pieces of clothing or equipment. Consequently these wounds are much more often infected. They may give rise to three classes of wounded: those with serious complications; those in whom the projectile causes disturbance; and those who experience no discomfort.

(a) On account of serious septic pleuro-pulmonary complications there is unfavorable prognosis in a certain number of wounded. These complications most often develop as acute febrile attacks. They are always serious, involving either the lung, the pleura, or both.

Pneumonia and broncho-pneumonia will be especially considered and abscess of the lung which, without treatment, may evacuate either into the bronchi producing a vomica, or into the pleura giving rise to an empyema; also putrid infections of the lung with fœtid gas production and pulmonary gangrene.

In the pleura a hemothorax is frequently seen which often has a tendency to suppurate more or less rapidly. An increasing number of polynuclears in the hemothorax contents indicates, according to Policard and Philip, an impending suppuration. Pleurisy which is purulent primarily or secondarily fills the entire large pleural cavity or only a portion (encysted pleurisy). Finally, partial or total pyopneumothorax is considered one of the most important pleural complications. Mediastinal abscess, with a serious prognosis, as reported by Mornard (Soc. Chirurgie, August, 1915) has also been pointed out.

In all these complications radioscopic examination is very useful in ascertaining or confirming the location which clinical signs have already indicated. As the special radiological images in each of these complications are well known and have been described elsewhere in detail, they will not be considered here.

(b) In other cases of wounds, the intra-pulmonary projectile gives rise to less violent and less acute symptoms but produces relapsing disturbances either as intermittent or chronic attacks.

They occur as successive attacks of febrile pulmonary congestion, recurring hemoptyses, chronic febrile bronchitis with emaciation and excessive sweating which suggests pulmonary tuberculosis, as was the case in a wounded patient referred to Barjon and Delore as tuberculous.

(c) Finally, the last class includes all who have no functional trouble from the projectile and show no pulmonary reaction discernible on auscultation and radioscopic examination. These classes will again be considered in connection with the discussion of indications and contra-indications for operation.

II. Radiological Study.—To be useful this study requires a series of investigations in which radioscopy and radiography are used successively. The two methods of exploration are inseparable.

Nature of projectiles.—They consist of metallic bodies: rifle or machine gun bullets, shrapnel, fragments of shell varying in form and dimensions. Sometimes these are accompanied by secondary foreign bodies, either broken off by the force of the collision such as splinters of bone torn off by the fracturing of surrounding bones: ribs, sternum, clavicles, scapulæ, vertebral column; or carried into the wound by the projectile itself such as pieces of clothing or equipment. The latter are not usually visible on radiological examination.

In brief, the different examinations are as follows:—First it will be necessary to find the projectile, then deter-

mine its general position and localize or mark it. Finally, it is necessary that indications for extraction be submitted to the surgeon.

1. *Search for projectile.*—To ascertain whether the projectile has lodged in the thorax or passed through it a general examination of the thorax is necessary. Radioscopy being quicker and more complete will be used first for a general exploration. Examination is made either in the standing or the dorsal decubitus position according to the condition of the wounded. The different positions for the examination of the thorax described in an earlier chapter should be used for discovering the projectile. Occasionally these metallic foreign bodies are very visible on account of the transparency of the thorax. Under certain circumstances they may pass unnoticed.

The projectile may be enclosed in a center of hepatization, in a purulent accumulation (pleurisy, lung abscess, etc.) which obscures its visibility. But the determining of these pathological centers is in itself important information. Another reason for the projectile not being seen is its extremely small size. Very small foreign bodies may pass unnoticed under the conditions of reduced visibility in radioscopic examination.

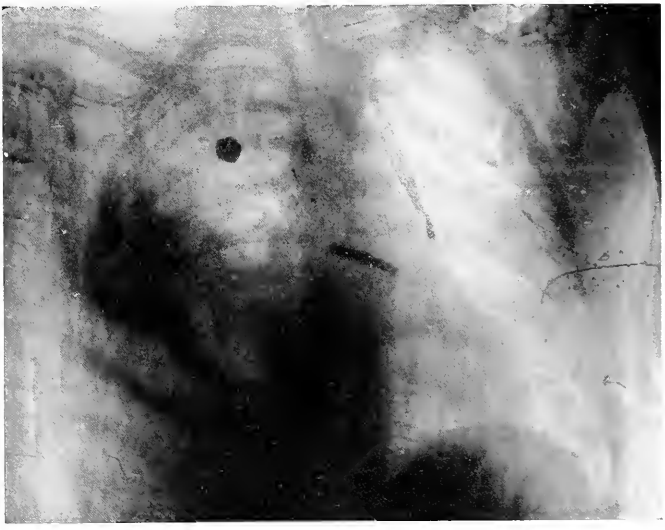
Negative examination ought never to lead to the conclusion that no foreign body is present, but determines simply the absence of a visible body.

On the other hand, what has not been seen radioscopically may appear on the photographic plate, which is infinitely more sensitive. When absolute certainty is desired, radiography must be practised under good conditions. Instantaneous or very rapid exposure should be used and with forced inspiration so as to produce the best possible conditions of visibility. Too long an exposure would give no more certainty than the radioscope, because respiratory movement would prevent the formation of any clear or even visible image of projectiles of small size.

2. *Position of projectile.*—The presence of a foreign body

RADIOGRAPH A. TRAUMATIC ENCYSTED HEMOTHORAX IN A CASE OF OLD PLEURISY

The bullet, after passing through the thorax, lodged in the wall. Pleurotomy, complete recovery, thorax became entirely clear from apex to base.



RADIOGRAPH B. PIECE OF SHRAPNEL IN THE RIGHT LUNG

Long splinter of shell in the posterior wall. Right pleurisy.

having been established, it is indispensable to use this same radioscopic examination for information as to the general position: whether the projectile is intra-thoracic, in the lung or in the pleura; or only in the wall.

Radioscopic examination sometimes suffices; if not, the findings should be supplemented by exact measurements. It is especially difficult when projectiles are at a tangent or at the extreme base. For projectiles at a tangent it ought to be determined whether the projectile is found within or without the costal grill by a series of oblique examinations with normal rays, used as near as possible.

For projectiles at the extreme base, situated in the cul-de-sac, it is sometimes difficult to establish their location, whether above or below the diaphragm. Examinations with forced inspiration and expiration are the most useful, but are not always possible on account of the complete or relative immobilization of the diaphragm. A slight effusion or pleural exudate may further complicate. The projectile may have caused a pleural reaction in the passage and may be fixed below the diaphragm. If the projectile or a part of its outline can be seen detached above the diaphragmatic dome in any position, it may be affirmed that it is either entirely intra-thoracic or partly included in the diaphragm.

Projectiles at the base may still be free in the pleural cavity, in which case they are movable with the different changes of position as reported by Gouilloud and Arcelin.

Radioscopic examination by showing the presence of pleuro-pulmonary reactions, already mentioned, is rather in favor of the existence of an intra-pulmonary foreign body. Besides it fixes the general position of the foreign body, and indicates whether the projectile is found in the superior or inferior lobe, whether it is in the region of the interlobar fissure, near the hilus and the large blood vessels, etc.; information which may be useful in later discussion.

3. *Localization.*—Exact measurement of the projectile. This process consists in determining the exact location of

the projectile and in indicating its relation to the surrounding organs and cutaneous regions by which it may be approached; in furnishing by exact measurement the distance in millimeters of the projectile, with some natural or artificial point of measurement, which may be useful to the surgeon in intervention.

Radiological methods of measurement are numerous. Many have appeared in radiological journals of the past two years.* Most are good, provided too much is not expected of them. It is difficult for one without experience to choose from among them.

Calculation of depth.—Under all these methods there is one basic fact,—the determination of the depth of the projectile. This essential measurement is obtained in different ways. One of the simplest, which requires no special apparatus, is a double exposure on the same plate.

The tube being placed at a given height above the plate, two successive half exposures are made. For the second exposure the tube is shifted a few centimeters horizontally. Two distinct images of the projectile are thus obtained on the plate and the distance between them can be exactly measured with a compass. Three facts are thus known: the height of the anticathode above the plate (H); the shifting of the anticathode for the second exposure (D); and finally the distance between the two foreign bodies on the plate (d).

By drawing straight lines which represent in the space the direction of the rays, similar triangles with approximating apices are obtained. By geometric calculation the formula is established $x = \frac{H \times d}{D + d}$ which gives the distance from the foreign body to the plate in known dimensions. In this way the first fundamental fact is obtained which

* See particularly the following articles: Belot and Fraudet, Procédé de repérage des projectiles (Journ. de Radiologie et d'Électrologie, Jan.-Feb. 1916). Albert Weill, Paris Médical, Feb. 5, 1916.

indicates in depth the location in the body of the foreign body sought for.

Surgical application.—This result, to be of use later to the surgeon, ought to be practically applied. The actual methods used can be grouped into three main classes according to the way in which this localization is done: first, by means of instruments (instrumental methods), second, by means of diagrams, marked plans, stereoscopic pictures (graphic methods), finally by locating projectiles in relation to certain definite anatomical landmarks (anatomical methods).

The instrumental methods seem to be most in use to-day. The greater part are based on the use of a directing compass, indicating usually in the course of intervention the direction and the distance of the foreign body.

The earliest of these instruments is the Hirtz compass, which is excellent. It is on his principle that all the others are based. It has the disadvantage of being delicate, of necessitating minute and long investigation, and of requiring the construction of a complicated diagram. In spite of all this it is still very much in use and is a very exact and excellent instrument.

Among the others is the Saissi compass which has been used by Henri Béclère and which Marion recommends.

This instrument, however, has been simplified and only the Debierne compass, the Massiot compass and the sector guide of Grandgerard will be considered. These three instruments are based on the same principle. It consists in taking the foreign body as the center of a sphere. This sphere is represented by an arc of a metallic circle on which a movable rod glides; this makes one of the rays. Whatever its position, this ray is always directed toward the center and indicates the direction and distance. The advantage to the surgeon is to be able to choose from among all these positions the one which seems the most favorable.

The graphic methods are also quite accurate, but their disadvantage is that they do not give directly any surgical

application. With an operator accustomed to the reading and interpreting of graphics, with the continuous aid of radiography, this procedure gives, however, good results. Nogier has proposed a simple and accurate graphic method.

In this class methods may be included which make use of stereoscopic pictures, so little used. However, a simplified stereoscope described by Chassard and Lahousse allows of the numerical determination of distance, which is dependable localization.

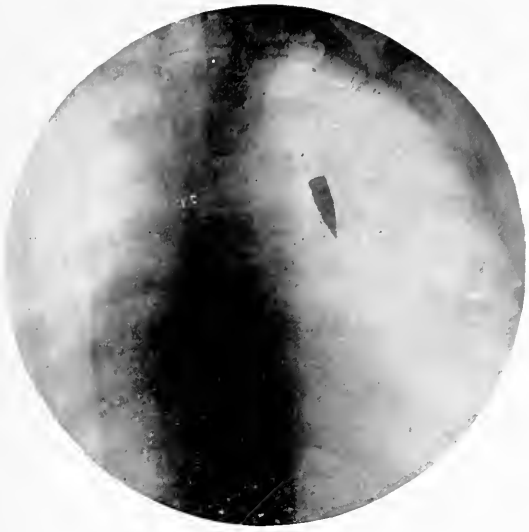
Anatomical methods are more truly surgical. They estimate the exact location of the projectile in relation to one or several anatomical marks. They have the advantage of allowing greater freedom to the surgeon who approaches the foreign body thus located, in the way which seems best. Arcelin has used one of these methods with success in a large number of cases.*

Difficulty of applying these methods in pulmonary cases on account of the mobility of the lungs.—It is first of all very important to note that conditions are quite different for intrapulmonary projectiles, on account of the very great mobility of the lung. This mobility is considerable and the movement of the foreign body in inspiration and expiration may amount to several centimeters. These movements are quite appreciable towards the apex where they easily measure a centimeter and much more important toward the base where the movement not uncommonly is from two to three centimeters.

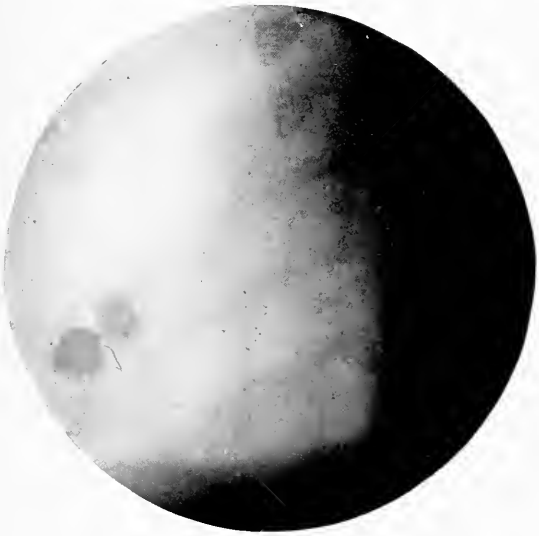
To this mobility is added that of the thoracic wall, which is very extensive, especially in front. The mobility of the lung, however, is far from being equal to that of the wall, especially if no adhesions are present.

An attempt has been made to distinguish between adherent and immobile lungs and free mobile lungs. This distinction has not the practical value which it is supposed to have.

* Arcelin. Localisation anatomique des projectiles de guerre. Paris Médical, February 5, 1916.



RADIOGRAPH A
Intra-pulmonary rifle bullet without appreciable reaction.



RADIOGRAPH B
Displacement in inspiration and expiration of an intra-pulmonary polygonal piece of shell and a triangular indicator on the anterior wall.

In fact, limited adhesions, which are most common, do not immobilize the lung; it continues to be moved, pulled by the wall to which it is attached. Displacement will be more limited if the adhesions are posterior, but its extent will still be considerable if the adhesions are anterior. In reality, displacement of the wall is very extensive during inspiration and expiration. It is easily demonstrated by making a double instantaneous exposure on the same plate in these two extreme positions. The angle of displacement described by the ribs continues to enlarge more and more, from the fixed dorsal part to the mobile sternal portion. Scarcely ever, except in pleurisy, would immobilization occur and there but seldom, and even in total symphysis absolute immobilization does not exist. Two practical conclusions may be drawn from these facts.

The first is that measurement of the depth of an intrapulmonary projectile by the method of double exposures on the same plate is subject to certain errors. In order that the measurement be accurate it is necessary that both exposures be made in exactly the same respiratory position, of which we can never be certain. It is often impossible to control patients and to keep them even for some moments in forced inspiration or expiration. Such patients breath in their own way and it is impossible to regulate them. Even in those cases which are closely observed and where there is co-operation, it can never be certain that two exposures made in succession with a definite interval elapsing will be found exactly in the same condition. Inspiration, for example, may be a little deeper in one than in the other.

Now, an inspiratory displacement of some millimeters and that caused by the moving of the tube must either be added or deducted; in every case they will distort the true estimate of the depth of the projectile, since it is based on the measurement of this displacement.

It is not possible, therefore, to obtain any measurement of foreign bodies in the lung so accurately as when they are lodged in an immobile portion of the body or limbs.

A second conclusion which may be drawn is that it is necessary in the lung to distinguish between localization and extraction. In the fixed portions of the body conditions are not changed between localization and extraction. Points of measurement and their distance in relation to the projectile remain always fixed. In the lungs this is not the case. At the time of intervention conditions become different from what they were at the time of localization, and displacement of the foreign body follows which may become important.

From anesthesia respiratory conditions are already changed. Even if the changes are unimportant, they become more important from the production of a pneumothorax which upsets all the relations of the lungs.

Objection will be made that the lungs are always attached to the wall in a slight degree. This fixation is sufficient for the surgeon because he can keep under his fingers the portion of lung which he wishes to explore, but from a physiological point of view it is only illusory; it only decreases displacement; it does not suppress it.

The surgeon may immediately come upon the projectile, but this will be because of his surgical instinct and keen sense of touch and not because the foreign body was indicated so many millimeters in such a direction; manifestly this could not be indicated on account of the pulmonary retractility. If the surgeon is fortunate enough to extract the projectile in spite of obstacles, it is certain that mobility, which may often be a hindrance, is not an insurmountable obstacle to successful intervention. Certain operative technique, that of Duval for instance, is even based on this mobility.

This does not imply that all localization is useless. It is only intended to show that too great exactness is illusory and almost impossible to obtain in foreign bodies in the lung and that besides, it is not indispensable in such cases in order to bring about good surgical intervention.

The function of the radiologist.—In determining the use of radiology to the surgeon distinction must be made as to

whether operation is necessary on account of pleuro-pulmonary complications or only because of the presence of a projectile.

a. In cases of complication, especially septic complication, as total or encysted purulent pleurisy, pyopneumothorax, hemothorax, lung abscess, pulmonary gangrene, etc., the projectile becomes of secondary importance. The surgeon must be informed as to the location and extent of the accumulation to be opened and drained in order that he may decide the method of approach. Sometimes in evacuating the collection, the foreign body will eliminate itself either immediately or after some days. If it is not eliminated, the complication should be allowed to clear up; then the projectile should be considered as in the case presently to be studied.

b. Cases where there is present in the lung a projectile which does or does not bring on a local reaction and the extraction only of which is to be considered.

An exact topography of the foreign body will be made first. At the same time the presence or absence of pulmonary reaction will be indicated as a dark zone around the projectile, diminution of clearness of the entire lung or of the lobe containing the metal fragment, decrease of pulmonary expansion and of the amplitude of respiratory movements. All these facts are useful for the discussion of indication or contra-indication for operation.

Localization must be carefully considered. It has been shown that in practice accurate determination is doubtful and not at all necessary. Nevertheless in this study all possible care should be employed and in making this localization each one should use the process to which he is accustomed, which he knows best how to apply with the minimum of errors.

Barjon considers, however, that it is better not to be content with any one indication, but that it is useful to determine the location and the depth of the projectile in relation to several points in the thoracic wall. A posterior, an anterior and a lateral point are ordinarily enough, but it is

easy to take others. By this method the surgeon is left a choice in approaching the foreign body. Radioscopic measurement may be used to establish these facts quickly with sufficient accuracy.

The method of Hirtz and Gallot described by Gallot in the Archives d'Électricité médicale (April, 1915, p. 115) gives readily and without any calculation the measurement of depth by means of a pierced screen and a plumb line.

To facilitate the work, when the wounded are strong enough, which is frequent, Barjon has modified this apparatus so as to take measurements in the upright position. He has replaced the plumb line by a solid graduated rod sliding into a cylinder fastened in front of the opening and always kept perpendicular to the surface of the screen, consequently in the axis of the normal rays of incidence.

This procedure is simple, convenient and quick; it does away with all errors in calculation and estimate of distance and displacement of the anticathode which does not even have to be taken into account.

One process alone would appear rational,—examination on the radioscopic table. The operating table should also be a radioscopic table so that brief examination can be made at intervals and the surgeon can be told just what location the foreign body occupies in relation to forceps or any other metallic instrument placed in the wound in a convenient manner. It is only necessary to supply a table with sufficient means of protection to safeguard the surgeon and his assistants, to use the least possible amount of X-rays and during very short lengths of time on account of the real danger of these examinations.*

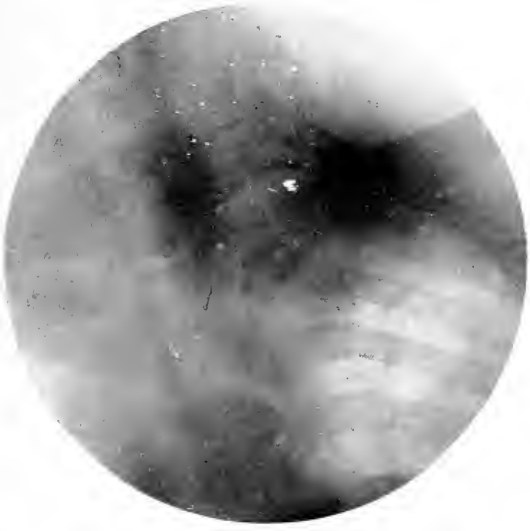
Other means of localization and direction may give as good results in the hands of experienced operators. Barjon emphasizes once more that the best method is that which one knows best and has practised most.

III. Course of Procedure. Indications and Contra-

* To the Wullyamoz table and the modified model of Arcelin attention is especially called.

RADIOGRAPH C

Large piece of shell, intra-pulmonary, very well endured for ten months. No appreciable reaction, no functional disturbance.



RADIOGRAPH D

Large piece of shell, intra-pulmonary, with important reaction. Obscurity of entire apex of the lung.

INDICATIONS FOR OPERATION.—The mode of procedure in penetrating wounds of the thorax is highly interesting to the radiologist, because in discussing the question of indications and contra-indications for operation, aside from clinical facts, medical and surgical, an important place ought to be given to radiological findings.

It is necessary, therefore, that the radiologist be in a position to appreciate exactly the value of the information obtained from his examination.

There are three groups of facts:

a. *Positive and urgent indication.*—The first group includes febrile infected patients with the appearance of being seriously ill. Radioscopic examination shows that the center of infection or suppuration is intra-thoracic. It shows extensive pathological shadows, of variable form and appearance. The images indicate the presence either of a pleural infection: total or encysted purulent pleurisy, hemothorax; or of a pleuro-pulmonary infection: pyopneumothorax, pleuro-pulmonary gangrene; or of a definite pulmonary accumulation: lung abscess. In all these cases indication for operation is not only positive but urgent. It is a case in which surgery is indicated for pleuro-pulmonary septic complications, which are already well established and recognized, rather than surgery which has to do with war projectiles.

If after intervention the projectile is not discharged, the wounded come into one of the following groups:

b. *Positive indication, not urgent.*—In the second group are included all those wounded who without any symptoms of serious infection or of apparent centers of suppuration have intrapulmonary projectiles which they do not stand very well.

In these patients there are seen clinically slight attacks of pulmonary congestion, or small pleural effusions, recurring hemoptyses, bronchitic attacks. Examination of the thorax shows diminution of resonance or even a definite dullness, modifications of sounds, increase or disappearance;

râles, ronchi, fremitus, respiration a little shallow, most often no respiratory sounds.

From a functional point of view these patients cough and expectorate, have dyspnœa, especially on exertion, tachycardia, thoracic pains brought on or increased by coughing and walking. General health is poor; some have intermittent febrile attacks, others grow pale and thin; some have been considered tuberculous until radioscopic examination disclosed the presence of a projectile.

Radiological examination not only shows the presence of the projectile and locates it, but furnishes also valuable indications which show considerable diminution in the functional value of the lung affected.

Sometimes there is diffuse obscurity, not very extensive, limited to the area around the projectile or immediate vicinity. Sometimes the obscurity extends to all the lobe involved and sometimes even to the entire lung. Vesicular expansion produced by forced inspiration or by coughing has entirely disappeared while it remains in the other lung.

The extent of the excursion of the diaphragm in respiratory movements is limited; at times added pleural exudates obscure the base, partially or totally effacing the contour of the diaphragm, immobilizing it and filling up the costal sinus.

In all cases of this class it is clear that the projectile is the only cause of all the trouble. There is still positive indication for operation but it is not urgent. The location of the foreign body and the reactions produced must be be studied all the time. Once all this knowledge has been collected, intervention can be undertaken.

c. *Debatable indications.*—Finally, the third and last group includes foreign bodies which are well tolerated. A certain percentage of the wounded show perfect tolerance. One soldier was known to have had a large piece of shell (25 by 15 mm.) in the right lung for ten months, without experiencing the least discomfort; there was no apparent

physical or functional disturbance on clinical or radioscopic examination.

Others possess less perfect tolerance and have very slight functional troubles, such as dyspnœa on slight exertion, palpitation, thoracic pain, nervous reflexes; but have no cough, no physical sign on auscultation, no febrile reaction. Barjon believes that in some of these cases suggestion may play a part in causing these slight disturbances.

This third class includes more debatable cases, which from the point of view of intervention, are acted on positively by some surgeons, negatively by others.

Marion and Duval believe positively in intervention. In their opinion every intra-pulmonary projectile ought to be taken out because it may become the starting point of a secondary infection, and because there is always a small center of suppuration around the projectile.

Certainly a projectile left in the lung, especially if it is of any size, is something abnormal, anti-surgical and consequently disturbing. It is a solution which is not entirely satisfactory. From a military point of view, according to many, every man who knows he has an intra-pulmonary projectile is lost. This argument, which may have some reason, is not actually a medical rule and will lose its value after the war.

A second class of surgeons do not believe in intervention. Certain projectiles are very well endured for a long time. Cases are quoted of fourteen to eighteen months' duration without any disturbance.

Intervention is not without danger. Cases of death have been reported. (Leriche's case with negative autopsy.)

Contra-indications.—Particular cases of contra-indication have been specified by some surgeons. Mauclaire points out the deep location of the projectile in the region of the large hilus blood vessels, which increases operative risk. Quénu points out as contra-indication multiplicity of projectiles which complicates operative technique.

Finally, not all surgeons are of the same opinion regarding

the local condition of the lung surrounding the foreign body. Some assert there is always a small center of suppuration. Others find in certain cases no trace of infection or suppuration. According to them, the projectile has been found in process of encystment in dense or entirely sclerosed pulmonary tissue.* This finding has a great value because it shows that certain projectiles may become encysted in the lung, be surrounded by sclerous tissue and perhaps later by calcareous infiltration as in a healed tubercle. In that case they may be tolerated indefinitely. It is clear that to judge this question well a lapse of some years is necessary.

Conclusion.—At present it must be concluded that no absolute rule can be admitted. It is not only a question of projectiles and operative technique; the wounded, the physicians and surgeons must be considered. The decision is a matter of clinical sense, of judgment, wisdom and professional conscience.

NOTE

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AFTER consultation with the Director of Roentgenology, American Expeditionary Forces, Major James T. Case, the Surgeon General's Office decided to adopt certain standard methods of localization. Of these three may be described as simple depth methods, giving the distance from the skin to the position of the projectile at the time of observation in a vertical direction. Three methods were also adopted which give, in addition to the depth, some indication of surgical approach or an indicator during operation.

Two of these will doubtless find considerable value in chest lesions. These are (1) the profondometer: this depends

* Belot (Journal de Radiologie et d'Électrologie, May–June, 1916) shows radiographically the formation of these fibrous cicatrices in the presence of a projectile.

upon the establishment of three lines of sight through the body and the projectile and the reproduction of the contour of the body in the plane of these lines, which, in connection with the cross section anatomy gives the surgeon an approximate depth from a variety of directions and a reasonably clear idea of the important organs to be penetrated or displaced in an attempt to remove the body.

The other method is the well-known Hirtz compass which in a great majority of cases will be a favorite of the surgeons. It will be possible in most of the chest lesions to acquire the data necessary for operating the compass by a fluoroscopic examination which will be very much more expeditious than the photographic method. This will undoubtedly greatly extend the usefulness of the compass and broaden its application.

Provision is also made for intermittent control so that the Roentgenologist may, in case of need, quickly make fluoroscopic observation in order to render assistance to the surgeon in case of difficulty. It is hoped that by co-operation on the part of the Roentgenologist and the surgeon that the simple methods adopted will serve the purpose, especially if the Roentgenologist will endeavor to give accurate anatomical information in addition to the more geometric localization.

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